1928h. Model of Wheel (probably for grinding). With sliding axle.

1928i. Fragment of Model (probably a pump bucket).

1928k. Models on a Stand, of four trussed beams, probably used experimentally for testing the strength of different methods of trussing.

1928l. Fragment of a Model of a Frame for a Machine.

1928m. Fragment of a Frame.

1928n. Model of a Horse Mill, with roller and trough, apparently designed for crushing material.

1928o. Model of a Train of Wheels.

1928p. Model of Beam and two connecting Rods with universal motion at their upper ends, and connected to transverse hinged links at their lower ends.

1928q. Model of Beam Pumping Engine, single acting and condensing, worked by tappet valve motion.

1928r. Model of double acting Beam Condensing Engine, conical valves worked by eccentric.

1928r. Model of inverted Cylinder direct-acting Pumping Engine, with tappet valve motion.

1928s. Sectional Model of Beam Engine, worked by eccentric and hollow valve.

1928t. Sectional Model of Engine, with shifting eccentric for altering valve.

1928u. Model of a Pair of Tilt Hammers, alongside each other. Two beams and connecting rods, with cranked pins at an angle to each other, and one of the wheels provided with a balance weight.

(NOTE.—Part of the above model missing.)

1928v. Fragment of a Model with part of Sun and planet motion.

1928w. Fragment of a Model with Sun and planet motion and weighted disc.

1928x. Fragment, an arch head.

1928y. Model of a Water Wheel.

1928z. Measuring Apparatus, with Micrometer Screw, for taking end measures.

1928aa. Model of Garnet's Patent Friction Rollers.

1928bb. Model used for Testing Pressure due to Vacuum.

1928cc. Model of Valve with Universal Joint.

1928dd. Brass Model in two Pieces.

1928ee. Model used in experiments on Governor.

1928ff. Experimental Model.

1928gg. Experimental Model.

1928hh. Experimental Model.

1928ii. Original Model of Cylinder with separate Condenser.

1828jj. Model of Surface Condenser.

III.—PRIME MOVERS.

a. Stationary Engines.

2019d. Papin's Steam Cylinder.

Royal Museum, Cassel (Director, Dr. Pinder).

This cast-iron cylinder was to have formed part of a large pumping engine, which, however, was never completed. The object was to supply a canal at the level of Hofgeismar with water, whereby the Landgraf Charles hoped to draw the traffic of the Weser to Cassel. An explosion which took place in Papin's laboratory when the Landgraf was contemplating a visit, led to the bold investigator withdrawing from the influence of his enemies. He came to England (1707), but did not succeed with his plans, and died in poverty. Papin's sketch of his contemplated pumping engine is exhibited with the cylinder. It was a peculiar combination of the Savery engine and the piston engine recommended by Papin for other purposes. In the closed boiler A (with safety-valve of Papin's design), steam was generated, which (on opening the cock C) could pass through pipe B to cylinder D. Here it pressed down the close fitting piston or float E which rested on water that had been supplied through the funnel I from a reservoir. The water was thus forced into the chamber F; its return was prevented by a valve at H; and the steam-cock C being now shut and the condensed steam allowed to escape from the upper part of D, water from the reservoir was admitted anew, and the process repeated. The water raised into F could be further directed through the tube G. Papin proposed to add to the effect by introducing red hot irons through the opening in the cover of the cylinder D. Of the two cylinders it is probably D that is exhibited.

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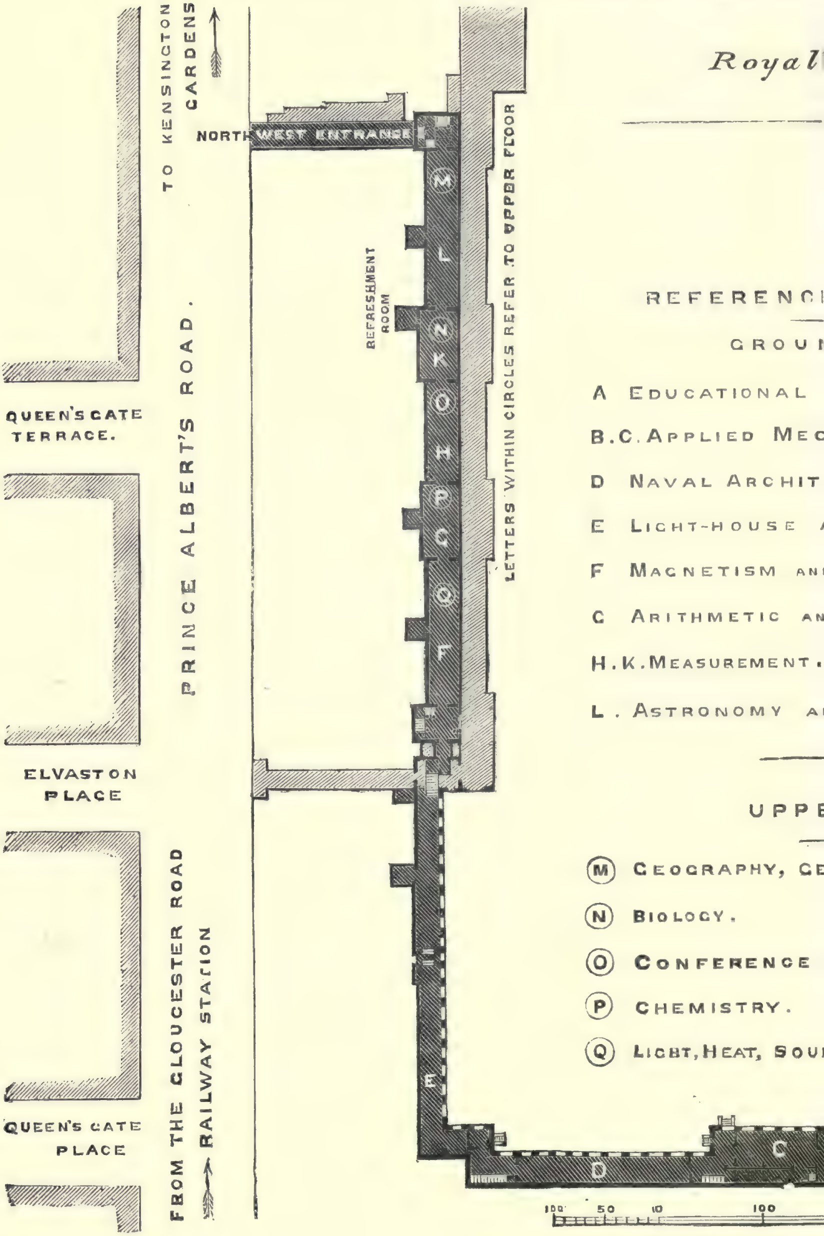

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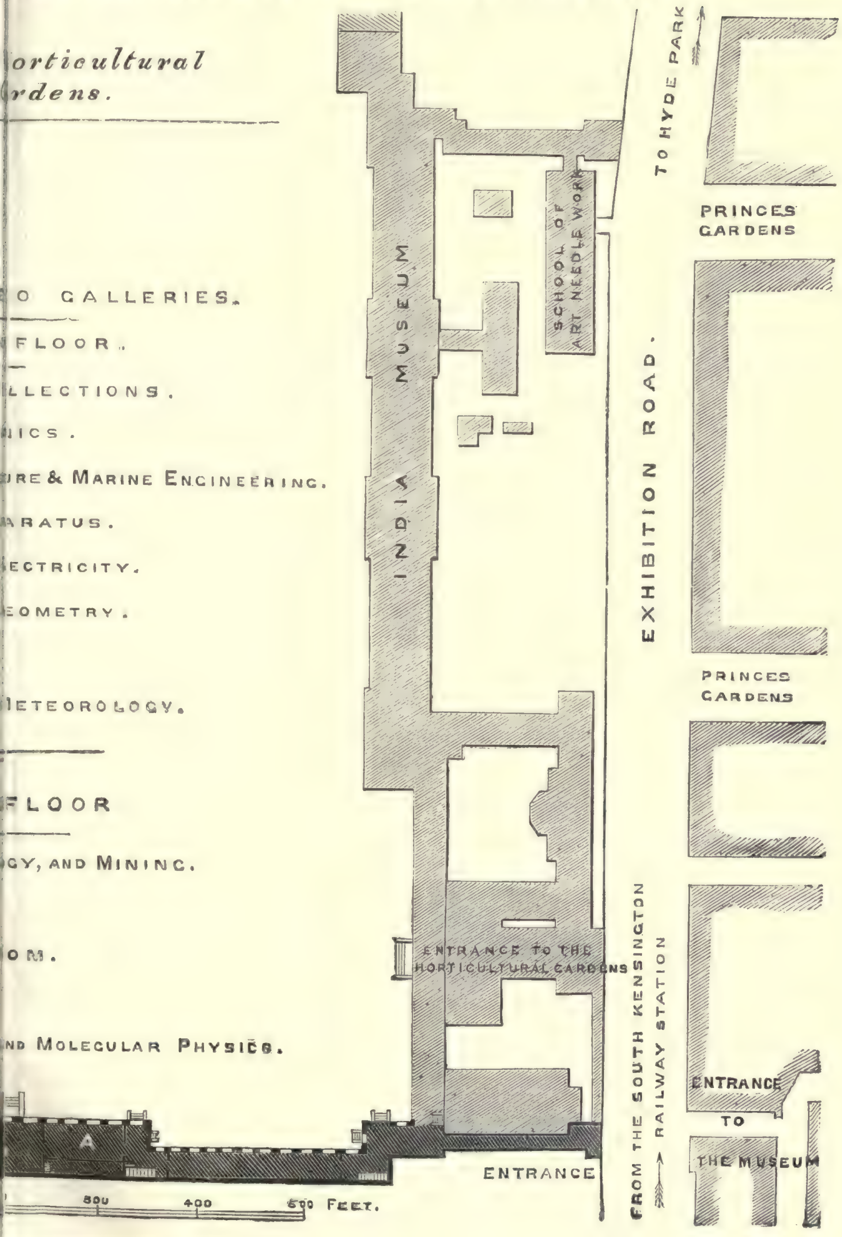

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PREFACE TO THE THIRD EDITION.

THE receipt of a large number of objects since the compilation of the Second Edition has rendered necessary the publication of a Third Edition, to afford a complete record of the collection for future reference. Every endeavour has been made to ensure its correctness. Slips from the former edition have been sent, wherever practicable, to the several contributors for their corrections, in order that all errors might, as far as possible, be eliminated.

Although a considerable amount of re-arrangement has been found necessary, it has been thought advisable to retain the numbers given to the objects in the former edition, as those numbers have already been quoted in the Handbook and other publications.

This edition has been revised and passed through the press by Mr. A. T. Atchison, to whom the thanks of my Lords are due for the great care and trouble he has bestowed upon it.

South Kensington Museum,
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INTRODUCTION.

By Minute dated 22nd January 1875, the Lords of the Committee of Council on Education approved of a proposal to form a Loan Collection of Scientific Apparatus, which was to include not only apparatus for teaching and for investigation, but also such as possessed historic interest on account of the persons by whom, or the researches in which, it had been employed. Their Lordships then invited some of the leading men of science of the country—the Presidents of the learned Societies and others—to act on a Committee to consider the matter, and aid them with their advice. This Committee, to whose exertions the formation of the collection is so largely due, consisted of—

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Mr. J. Torr, M.P.
Rev. J. F. Twisden, M.A.
Professor Tyndall, LL.D., F.R.S.
Professor W. C. Unwin, B.Sc.
Mr. C. V. Walker, F.R.S., President of Society of Telegraphic Engineers.
Mr. F. H. Wenham.
Sir C. Wheatstone, F.R.S. (since deceased).
Sir J. Whitworth, Bart., F.R.S.
Professor A. W. Williamson, Ph.D., F.R.S.
Mr. Bennet Woodcroft, F.R.S.
Dr. J. Woolley, F.R.S.
Colonel H. Stuart Wortley.

The first meeting of this Committee was held on the 13th February 1875; the number of those who were present showing the interest already felt in the subject. The Lord President of the Council, the Duke of Richmond, and the Vice-President, Viscount Sandon, in explaining the objects of the Collection, took occasion to refer to the recommendations of the Royal Commission on Scientific Instruction, with regard to the creation of a Science Museum.

Their Lordships stated their conviction that the development of the Educational, and certain other, Departments of the South Kensington Museum, and their enlargement into a Museum somewhat of the nature of the *Conservatoire des Arts et Métiers* in Paris, and other similar institutions on the Continent, would tend to the advancement of science, and be of great service to the industrial progress of this country. While expressing their hope that the Loan Collection might forward this desirable object, their Lordships guarded themselves against committing Her Majesty's Government, which had not yet fully considered the subject, to any definite scheme.

On the motion of the President of the Royal Society, Dr. Hooker, it was unanimously resolved by the meeting that an exhibition such as that proposed would be most instructive and valuable.

The question of the limits of the collection were discussed, and Sub-Committees were appointed to consider the limitations it might be desirable to place on the term "scientific apparatus" in the respective sections, while bearing in mind the space disposable for the exhibition in the Museum. As a provisional arrangement five Sub-Committees of sections were appointed, to whom it was left to suggest such modifications in classification as might be found advisable.

The sections were—

1. Mechanics (including pure and applied mathematics).
2. Physics.
3. Chemistry (including metallurgy).
4. Geology, Mineralogy, and Geography.
5. Biology.

The Committees for the several sections are given at page xxv.

The question of classification, having been carefully considered at numerous meetings of these Sub-Committees, was brought before the General Committee on the 12th May, and the several schemes were referred to a special Sub-Committee, formed of three members from each sectional Sub-Committee. It was also decided to postpone the Exhibition, which it was originally intended to open in June 1875, to March 1876. The large number of objects sent from abroad, and the late period of their arrival, have necessitated a further postponement of the opening to May 1876.

The Sub-Committee appointed to revise and report on the classification of the Collection after three meetings, under the chairmanship of the President of the Royal Society, submitted a scheme of classification to the General Committee on June 22nd. After having been carefully considered, it was, with some slight alterations, approved, and is given at page xix. This programme was immediately issued, and the classification into sections is that adopted for the catalogue and exhibition, though the nature of the Galleries has necessitated some alteration in the order of the sections.

It had been the intention from the first to give the Loan Collection an international character, so as to afford men of science and those interested in education an opportunity of seeing what was being done by other countries than their own in the production of apparatus, both for research and for instruction—an opportunity which it was hoped would be of advantage also to the makers of instruments. As soon, therefore, as the programme had been definitely settled, steps were taken to interest foreign countries in the Exhibition; and it was determined to obtain the co-operation of men of science on the Continent, who, while acting as members of the General Committee, should form special Sub-Committees charged with the due representation of the science of their respective countries.

It was necessary to take special precautions to prevent misunderstanding as to the character of the Collection. The mention of internationality at once suggested the idea of an International Exhibition similar in its character and arrangements to the numerous Industrial Exhibitions which have been held in various countries. A wrong impression of this kind would have entailed serious inconvenience.

In International Exhibitions a certain amount of space is allotted to each country. These spaces are then divided by the Commissioners of each country among its exhibitors, who display their objects—subject to certain general rules of classification—as they consider most advantageous, retaining the custody of their own property. The expenses of transport, arrangement, &c., are borne by the countries who exhibit. And the Exhibitions appeal naturally, more or less exclusively, to the industrial or trade-producing interests of those countries.

This was not the idea of the proposed Loan Collection at South Kensington. For that Collection it was desired to obtain not only apparatus and objects from manufacturers, but also objects of historic interest from museums and private cabinets, where they are treasured as sacred relics, as well as apparatus in present use in the laboratories of professors. The transport of all objects was undertaken by the English Government, and they were to be handed over absolutely to the custody of the Science and Art Department for exhibition; the arrangement being not by countries but strictly according to the general classification.

So soon as the object and scope of the Collection were thoroughly understood, the Committee of Council on Education met with the most gratifying responses to their invitations, which were communicated officially through the Foreign Office. Her Majesty's Ministers at Paris, Berlin, St. Petersburgh, Vienna, Florence, Brussels, the Hague, Stockholm, Madrid, Berne, and Washington, have personally interested themselves in the matter. And the Foreign Governments have afforded every facility and encouragement in forwarding this strictly international undertaking.

The subjoined list of the foreign members of the General Committee speaks for itself by the eminence and European reputation of its members.

BELGIUM.

M. Stas, Membre de l'Académie Royale (President).

M. le Général Brialmont, Président de l'Académie Royale et Inspecteur Général du Génie.

M. Dewalque, Membre de l'Académie Royale, Professeur de Géologie et de Minéralogie à l'Université de Liége.

M. Maus, Membre de l'Académie, Inspecteur Général des Ponts et Chaussées.

M. Plateau, Membre de l'Académie Royale, F.R.S.

M. Schwann, Membre de l'Académie Royale, Professeur à l'Université de Liége.

M. Van Beneden, Membre de l'Académie et Professeur à l'Université de Louvain, F.R.S.

M. le Général Liagre, Secrétaire perpétuel de l'Académie Royale, et Commandant et Directeur des Études de l'École Militaire (Secretary).

FRANCE.

M. le Général Arthur Jules Morin, Membre de l'Académie des Sciences, Directeur du Conservatoire des Arts et Métiers (President).

M. Alexre. Edmond Becquerel, Membre de l'Académie des Sciences, Professeur au Conservatoire des Arts et Métiers, F.R.S.

M. Henri Marie Bouley, Membre de l'Académie des Sciences, Inspecteur Général des Écoles Vétérinaires.

M. Gabriel Auguste Daubrée, Membre de l'Académie des Sciences, Directeur de l'École des Mines.

M. Jean Louis Armand de Quatrefages de Bréau, Membre de l'Académie des Sciences, Professeur au Museum d'Histoire Naturelle.

M. Jean Baptiste Dumas, Secrétaire perpétuel de l'Académie des Sciences, F.R.S.

M. Hervé Auguste Etienne Albans Faye, Membre de l'Académie des Sciences, Président du Bureau des Longitudes.

M. Edmond Frémy, Membre de l'Académie des Sciences, Professeur au Museum d'Histoire Naturelle.

M. Jules Célestin Jamin, Membre de l'Académie des Sciences, Professeur á l'École Polyetchnique.

M. Lenglet,Consul Général de France à Londres.

M. Urbain Jean Joseph Le Verrier, Membre de l'Académie des Sciences, Directeur de l'Observatoire, F.R.S.

M. Eugène Melchior Peligot, Membre de l'Académie des Sciences, Directeur des Essaisà la Monnaie.

M. Henri Edouard Tresca, Membre de l'Académie des Sciences, Sous-Directeur du Conservatoire des Arts et Métiers (Secretary).

GERMANY.

I.—Berlin Committee.

Dr. A. W. Hofmann, Professor of Chemistry, F.R.S. (President).

Dr. Beyrich, Professor of Geology.

Dr. du Bois-Reymond, Professor of Physiology.

Dr. Dove, Professor of Physics, F.R.S.

Dr. Förster, Director of the Observatory.

Dr. Hagen, President of the Board of Works.

T. G. Halske, Telegraphic Engineer.

Dr. Hauchecorne, Director of the School of Mines.
Dr. Helmholtz, Professor of Physics, F.R.S.
Dr. Kiepert, Professor of Geography.
Dr. G. Kirchhoff, Professor of Physics, F.R.S.
Dr. Kronecker, Professor of Mathematics.
Dr. C. D. Martius, Chemist.
Von Morozowicz, General.
Dr. Neumayer, Hydrographer of the Imperial Admiralty.
Dr. Reuleaux, Director of the Polytechnic Academy.
Dr. Schellbach, Professor of Mathematics.
Dr. Werner Siemens, Telegraphic Engineer.
Dr. Virchow, Professor of Pathology.
Dr. C. H. Vogel, Astronomer.
Dr. Websky, Professor of Mineralogy.

II.—COMMITTEE REPRESENTING OTHER CITIES AND TOWNS OF GERMANY.

Dr. Von Babo, Professor of Chemistry, Freiburg.
Dr. Beetz, Professor of Physics, Munich.
Dr. Buff, Professor of Physics, Giessen.
Dr. Clausius, Professor of Physics, Bonn, F.R.S.
His Excellency Dr. Von Dechen, Director of the Mining Department, Bonn.
Dr. Von Fehling, Professor of Chemistry, Stuttgart.
Dr. Von Feilitzsch, Professor of Physics, Greifswald.
Dr. Graebe, Professor of Chemistry, Königsberg.
Dr. Von Groddeck, Director of the School of Mines, Klausthal.
Dr. Heeren, Professor of Chemistry, Hanover.
Dr. Hittorf, Professor of Chemistry, Münster.
Dr. Karsten, Professor of Physics, Kiel.
Dr. Karsten, Professor of Physics, Rostock.
Dr. Knapp, Professor of Chemistry, Braunschweig.
Dr. Knoblauch, Professor of Physics, Halle.
Dr. Kölliker, Professor of Physiology, Würzburg, F.R.S.
Dr. Kundt, Professor of Physics, Strasburg.
Dr. Launhardt, Director of the Polytechnic School, Hanover.
Dr. Möhl, Cassel.
Dr. Poleck, Professor of Chemistry, Breslau.
Dr. Preyer, Professor of Physiology, Jena.
Dr. Von Quintus-Icilius, Professor of Physics, Hanover.
Dr. Reusch, Professor of Physics, Tübingen.
Dr. Romberg, Professor in the Nautical School, Bremen.
Dr. Rosenthal, Professor of Physiology, Erlangen.
Dr. Rümker, Director of the Observatory, Hamburg.
Dr. Serlo, Director of the Mining Department, Breslau.
Dr. C. Von Siemens, Professor in the Agricultural Academy, Hohenheim.
His Excellency Dr. Von Steinbeis, President, Stuttgart.
Dr. W. Weber, Professor of Physics, Göttingen, F.R.S.
Dr. Wiedemann, Professor of Physical Chemistry, Leipzig.
Dr. Winkler, Professor of Metallurgy, Freiberg.
Dr. Wöhler, Professor of Chemistry, Göttingen, F.R.S.
Dr. Wüllner, Professor of Physics, Aachen.
Dr. Zeuner, Director of the Polytechnic School, Dresden.
Dr. Zetzsche, Director of the Polytechnic School, Chemnitz.

ITALY.

Il Com. Blaserna, Professor of Physics and Rector of the Royal University of Rome.
Il Com. Cantoni, Professor of Physics at the Royal University of Pavia.
Il Cav. Respighi, Professor of Astronomy in the Royal University o Rome, and Director of the Observatory of the Campidoglio.

THE NETHERLANDS.

Professor Dr. P. L. Rijke, Conseiller d'État (President).
Professor Dr. H. G. de Sande Bakhuyzen.
Professor Dr. C. H. D. Buys Ballot.
Professor Dr. J. Bosscha.
Professor Dr. F. C. Donders, F.R.S., President of the Royal Academy of Science, Amsterdam.
Professor Dr. J. W. Gunning.
Professor Dr. R. A. Mees.
Professor Dr. V. S. M. Van de Willigen.
Dr. D. de Loos, Director of the Secondary Town-School of Leyde (Secretary).

NORWAY.

Professor Esmark.
Herr Mohn, Director of the Meteorological Institute of Norway.
Professor Waage.

RUSSIA.

M. Struve, Conseiller Privé, Directeur de l'Observatoire Central Nicolas (President).
M. Ovsiannikow, Membre de l'Académie.
M. Gadolin, Membre de l'Académie.
M. Gruber, Professeur de l'Académie de Médécine et de Chirurgerie.
M. Stubendorf, Colonel d'État-Major.
M. Wyschnegradsky, Professeur d l'Institut technologique.
M. Beilstein, Professeur de l'Institu technologique.
M. Barbot de Marny, Professeur d l'Institut des Mines.
M. Koulibine, Professeur de l'Institu des Mines.

SWITZERLAND.

Professor E. Wartmann (President).
Professor J. Amsler Laffon.
Professor D. Colladon-Ador.
Professor Dr. F. A. Forel.
Professor Dr. E. Hagenbach-Bischoff.
Professor Ad. Hirsch.
Professor Albert Mousson.
M. E. Sarasin-Diodati.
Professor L. Soret.
Colonel Gautier (Secretary).

AUSTRIA AND HUNGARY.

The Minister of Public Instruction has appointed Sectionschef Fidler t organise the contributions from these countries.

SPAIN.

No committee has been formed, but the Government has promised to contribute, and Señor Riano has been specially appointed to make the necessary arrangements.

UNITED STATES.

The Government has, through Mr. Fish, replied that it is in communication with the various departments and scientific institutions with the object of forwarding the Exhibition.

When men of this position in all branches of science have given their adhesion to the programme of such an Exhibition, its success might well be considered as secured. But these gentlemen did not rest satisfied with merely giving their names in recognition of its value: they have spared no time and labour in making the undertaking a real success. And the Lords of the Committee of Council on Education feel assured that, in offering them their thanks for their invaluable services, they convey not only their own sentiments but the grateful recognition of their labours by the country at large.

It will be readily understood from what has been said of the nature, scope, and method of the Exhibition that a large staff was required, in addition to the permanent staff of the Museum, to organise and arrange the collection in the limited time which could be afforded for that purpose. Special arrangements had, therefore, to be made; and their Lordships have great satisfaction in recording the names of those gentlemen who have rendered very valuable services—many of them as volunteers—greatly aiding the staff of the Museum in their laborious duties. These were Captain Abney, R.E.; Dr. Atkinson; Mr. Bartlett; Dr. Brunton; Dr. Biedermann; Professor Crum-Brown; Captain Fellowes, R.E.; Professor Carey Foster; Dr. Michael Foster; Herr Kirchner; Professor Goodeve; Dr. Guthrie; Commander T. A. Hull, R.N.; Mr. Iselin; Mr. Judd; Mr. Norman Lockyer; Dr. R. J. Mann; Mr. Clements Markham; Professor H. MacLeod; Professor Roscoe; Professor Shelley; Dr. Burdon Sanderson; Dr. Schuster; Dr. Voit; and Mr. R. Wylde.

To those men of science, who, in this matter and in the work of the General Committee and Sub-Committees, have given much valuable time, and have afforded them the benefit of their great knowledge and experience, the Lords of the Committee of Council on Education feel their best thanks are due, and they trust that the immediate success and future results of the Exhibition, which owes so much to them, will reward them for the labours which they have ungrudgingly devoted to it.

In order to make the Collection as useful and interesting as possible, a Handbook containing introductory notices to the several sections has been prepared. For writing these notices the Lords of the Committee of Council on Education have been fortunate in securing the services of gentlemen the mention of whose names will be a sufficient indication of the character of the work. These gentlemen are—

Capt. W. de W. Abney, R.E.
Professor W. Kingdon Clifford, M.A., F.R.S.
Capt. J. E. Davis.
Professor G. Carey Foster, B.A., F.R.S.
Professor Geikie, F.R.S.
Professor Goodeve, M.A.
Professor Guthrie, F.R.S.
Professor T. H. Huxley, LL.D., Secretary of the Royal Society.
Mr. J. Norman Lockyer, F.R.S.
Professor MacLeod.
Mr. Clements Markham, C.B., F.R.S.
Mr. N. Story Maskelyne, M.A., F.R.S.
Professor J. Clerk Maxwell, M.A., F.R.S.
Mr. R. H. Scott, M.A., F.R.S.
Professor H. J. S. Smith, M.A., F.R.S.
Mr. W. Warington Smyth, M.A., F.R.S.
Mr. H. C. Sorby, F.R.S.
Mr. W. Spottiswoode, M.A., LL.D., F.R.S.
Dr. W. H. Stone.
Professor P. G. Tait, M.A.

It had been originally proposed to exhibit the Collection of Scientific Apparatus in the South Kensington Museum; but various circumstances, which could not be foreseen, having rendered it necessary to abandon this intention, Her Majesty's Commissioners for the Exhibition of 1851, most liberally placed the galleries on the western side of the Horticultural Gardens at the disposal of the Science and Art Department. Though, unfortunately, these galleries are disconnected from the Kensington Museum, they are admirably adapted to the present purpose, and afford an accommodation which could not otherwise have been obtained.

By order,
F. R. SANDFORD,
Secretary, Committee of Council
on Education.

CLASSIFICATION OF THE COLLECTION.

Arithmetic.

Apparatus for teaching arithmetic. — Calculating machines.—Instruments for solving equations.—Slide rules.—Numbering and enumerating apparatus, &c.

Geometry.

Instruments used in geometrical drawing.—Methods of copying—Pantigraph, micrograph.—Peaucellier's cell and parallel motion—Machines for description of curves and specimens of the curves they describe, including geometric turning.—Instruments for giving graphic representations of phenomena.—Models to illustrate descriptive geometry.—Specimens to illustrate the process of making models according to a design.—Models to illustrate solid geometry, perspective, crystallography, &c. — Stereoscopic illustrations of solid geometry.

Measurement.

Of length.—Standard yard, metre, &c.—Comparator for standards of length (sight and touch). — Gauges, measuring wheels, steel tapes, &c.—Micrometers and verniers.—Cathetometers.

Of area.—Planimeters, &c.

Of volume.—Standard gallon, litre, &c. — Pipettes, burettes.—Meters for gas, water, &c.

Of angles. — Divided circles, theodolites, clinometers, goniometers, &c.

Of mass.—Standard pound, kilogramme, &c. — Vacuum and other balances.

Of density.—Specific gravity bottles, areometers, &c.

Of time.—Clocks and pendulums, chronometers, watches, and balance wheels.—Tuning forks for measuring small intervals of time.—Chronographs.

Of velocity.—Such as Morin's machine.—Strophometers, current meters, ships' logs, &c.

Of momentum.—Ballistic apparatus.

Of force.—Spring balances, pressure gauges, torsion balances, &c.

Of work.—Indicators, dynamometers, &c.

Kinematics, Statics, and Dynamics.

Elementary illustrations.—Position and displacement of a point, a rigid body, or a material system.—Composition and resolution of displacements.—Velocity and acceleration, their composition and

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resolution.—Displacements of a connected system.—Principles of mechanism.—Rolling contact, sliding contact, belting, link connexions, shafting, universal joints, &c.—Transmission of work.—Relation between the displacement of two pieces of a machine and the forces which they transmit.—The mechanical powers.—Instruments for illustrating the laws of motion, such as pendulums, gyroscopes, dynamical tops.

Laws of fluid pressure; stability of floating bodies.

Discharge of fluids through orifices, and their motion in channels.

Hydraulic and pneumatic transmission of power.

Molecular Physics.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with :—

Pressure on Matter.—Tension, Compression (piezometer) Torsion, Flexion; Relation of volume to pressure; Elasticity of liquids and gases.—Hardness (of solids and liquids), Toughness, Brittleness, Malleability, &c.

Communication of Pressure through Fluids.—Pressure of air, its consequences and applications.—Barometers, Air-pumps, Siphons, Suction-pumps, Spirators, &c.; Pressure of water, its consequences and applications,—Levels, Side pressure, &c.

Density.—Methods of measuring densities of Gases, Vapours, Liquids, Solids.

Adhesion and Cohesion.—Condensation of gases in solids, Solution of gases in liquids, Mixing of gases with gases (Diffusion, Transpiration, &c.), Absorption of liquids by solids (Capillarity, &c), Absorption of liquids by gases (Evaporation, &c.), Mixing of liquids with liquids (Osmose, Diffusion Dialysis).—Evaporation of solids, Solution of solids, Mixture of solids with solids (Cementation, &c.).

Sound.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with :—

Geometrical, Mechanical, and Optical methods of Illustrating the Laws of Wave Motion.—Progressive waves, Composition of Vibrations, Interference, Stationary waves.

Generation of Sound.—Fog-horn, &c.

Conduction of Sound.—Through solids, liquids, and gases, Stethoscopes.

Velocity of Sound.

Detection of Sound.—Sensitive flame, &c.

Reflexion and Refraction.—Ear trumpets, Acoustic lenses, &c.

Dispersion and Absorption.

Musical Sounds.—Pitch, Standards of Pitch, Standard Tuning Forks, &c.; Methods of measuring and comparing rates of vibration; Toothed wheels, Syrens, &c.; Vibration Microscopes, &c.; Methods of illustrating the nature of musical intervals; Manometric flames, Mirrored Tuning Forks, &c.

Musical Quality.—Illustrations of the different quality of the sounds of various instruments, Harmonics, and overtones, Resultant tones, Instruments for studying quality, Resonators, Phonautographs, &c.

Musical Instruments Illustrating the above.—Methods o exhibiting the mode of vibration of various instruments and the quality of the sounds yielded by them.

Light.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with:—

Production.—Combustion, Electric discharge, &c.

Measurement of Intensity, Velocity.

Action of Matter on Light.—Reflection, Refraction, Dispersion, Achromatism, Direct vision prisms, Polarization, Absorption (colour), Fluorescence, &c.

Action of Light on Light.—Interference, Diffraction, Measurement of wave length (optical banks), &c.

Action of Light on Matter.—Photography, Radiometry, Phosphorescence, &c.

Technical Applications of Optical Principles.—Lighthouse—illumination, &c.

Heat.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with:—

Sources of Heat.—Chemical, Electrical, Dynamical, Solar, Calorescence, &c.

Effects of Heat on Matter.—Changes of Temperature, Expansion and change of Elasticity, Liquefaction, Vaporization, &c.

Measurement of Temperature.—Thermometers, Pyrometers, &c.

Propagation of Heat.—Radiant Heat,—Radiometer, Reflexion, Refraction, Radiation, Absorption, Polarization; Conduction,—Solids, Liquids, Gases; Convection,—Ventilation, &c.

Effect of change of Molecular State on Temperature.—Freezing mixtures, Ice machines, &c.

Effect of change of Pressure and Volume.

Heat Quantity.—Unit of Heat, Calorimeters, Specific Heat, &c. Methods of determining Latent Heat.

Mechanical Equivalent of Heat.—Methods of determining. Illustrations of Thermodynamics.

Electrical Equivalent of Heat.—Methods of determining.

Analysis of Solar Radiation.

Magnetism.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with :—

Natural Magnets.

Permanent Artificial Magnets.

Electro-Magnets.

Methods of Magnetization.—Effects of Magnetization. Conditions affecting intensity of Magnetization :—Temperature (chemical), Composition, Strains, &c.

Magnetic Induction of all Substances.—Diamagnetism.

Measurement of Intensity of Magnetization, Magnetic moment.

Terrestrial Magnetism.—Instruments for observation and automatic registration of the magnetic elements.

Electricity.

Instruments and apparatus employed in teaching, and in the investigations and observations connected with :—

Production and Maintenance of Difference of Potential.—Electrical machines acting by friction, induction (doublers, replenishers, &c., Holz's and Töppler's machines, &c.) ; Galvanic batteries ; Thermo-electric piles ; Magneto-electric machines. Other sources, such as Pyro-electricity, Pressure electricity, Cleavage, Capillarity, Osmose, &c.

Detection and Measurement of Difference of Potential.—Electroscopes, Electrometers, Standards of electro-motive force, Methods of comparison.

Accumulation of Electricity.—Insulators, Condensers, Accumulators, Effects due to accumulated electricity, Distribution on conductors, Polarization of dielectrics, &c.

Measurement of Electric Quantity.—Torsion balances, Standard accumulators, Methods of comparing electric capacities and dielectric coefficients.

Detection and Measurement of Electric Currents.—Galvanoscopes, Galvanometers, Voltameters, Electro-dynamometers, &c.

Resistance.—Standards of resistance, Methods of comparing resistances, Methods of establishing absolute standards (British Association unit appar.).

Effects of Electric Currents.—Production of light, heat, Electrolysis, Electro-diffusion. Action on magnets, soft iron (electro-magnets), Action of currents on currents.

Technical Application of Electricity.—Electric telegraph, &c.

Astronomy.

Star maps, catalogues, globes, orreries, &c.
Meridian instruments.
Arrangements for communicating true time.
Altazimuths, zenith-sectors, sextants, &c.
Equatoreal Telescopes { Reflectors.
  Refractors.
Micrometers.
Driving clocks.
Special arrangements for—
  Celestial photography.
  Spectroscopic observations.
  Thermo-electric observations.
Siderostats.

Applied Mechanics.

As the Exhibition must be regarded as chiefly referring to education, research, and other scientific purposes, it must in this division consist principally of models, diagrams, mechanical drawings, and small machines, illustrative of the principles and progress of mechanical science, and of the application of mechanics to the arts.

Properties of Materials.
Structures at Rest and in Motion.
Prime Movers.
Reservoirs of Energy.
Regulators.
The Application of the Principles of Mechanics to Machinery as used in the Arts.
Shipping, Naval Architecture, and Marine Engineering.

Chemistry.

Scientific instruments, apparatus, and materials employed in the investigation and teaching of Chemical Science, and in the application of its principles to scientific purposes.

Diagrams and models.
Illustrations of analytical results.
Specimens of chemicals,—(*a*) organic, (*b*) mineral.
Apparatus and fittings for laboratory and lectures.
Apparatus for gravimetric and volumetric operations.
Apparatus for distillation and filtration.
Apparatus for operations by the dry or hot method, such as furnace, blowpipe, &c.
Refrigeratory apparatus.
Apparatus for spectrum analysis.

Note.—Operations of the following nature may be illustrated, viz.:

Organic analysis.
Mineral analysis.
Electrolysis.
Water analysis.
Gas analysis.
Spectrum analysis.
Methods of investigation connected with vegetation and respiration.

Meteorology.

Thermometers and barometers, of special construction.
Anemometers, rain gauges, hydrometers, &c.
Self-recording meteorological apparatus.
Illustrations of various systems of storm signals.
Weather maps.
Instruments illustrating the phenomena of atmospheric electricity.
Instrument stands.

Geography.

Instruments used in surveying.
Instruments used in Geodesy and Hydrography, including hypsometrical instruments, tide gauges, &c.
Projections, maps, charts, models, and globes.
Deep-sea sounding apparatus. Seismographical instruments.

Geology and Mining.

Instruments for field and underground surveying.
Typical collections of rock specimens, including vein stones.
Typical fossils arranged stratigraphically.
Maps in different stages, and finished maps.
Geological models, horizontal and vertical sections.
Diagrams and plates of fossils, and general geological diagrams used in lecture rooms.
Microscopic sections of rocks and minerals, and apparatus for cutting such sections.
Anemometers, water gauges, mining barometers, and thermometers.
Mining plans, sections, and models of workings.

Mineralogy, Crystallography, &c.

Goniometers.
Apparatus for studying and exhibiting the optical characters of crystals.

Sections for optical examination.

Blowpipe and other portable apparatus for determining minerals.

Collections of crystals, models of crystals, plates of crystals, and apparatus for drawing them.

Educational collections of minerals, &c.

Diagrams and models for lecture rooms.

Biology.

1. Microscopes with accessory apparatus for biological research, &c.
2. Physiological apparatus for investigating—
    - *a.* The growth and mechanical movements of living organisms and their parts.
    - *b.* The chemical phenomena of living organisms.
    - *c.* The electrical phenomena of living organisms.
    - *d.* The functions of the nervous and other systems.
3. Apparatus for anatomical research.
4. Apparatus for collecting and preserving object of natural history.
5. Appliances for teaching biology.

A limited number of examples illustrating the performances of the apparatus will be admissible.

Sub-Committees of Sections.

SECTION I.—MECHANICS, INCLUDING PURE AND APPLIED MATHEMATICS AND MECHANICAL DRAWING.

Professor J. C. Adams, M.A., F.R.S.
Mr. J. Anderson, LL.D., C.E.
Professor R. Stawell Ball, LL.D., F.R.S.
Rev. A. Barry, D.D.
Mr. W. B. Baskcomb.
Mr. Hugh Birley, M.P.
Major Bolton.
Professor F. A. Bradley.
Mr. F. J. Bramwell, F.R.S.
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Geological Survey of Scotland (Prof. Geikie, F.R.S., Director), *Edinburgh*; 827.

Geological Survey of the United Kingdom (A. C. Ramsay, LL.D., F.R.S., Director-General), *Jermyn Street, London*; 823–8.

George, Capt. C., *Royal Geographical Society*, 1, *Savile Row, London*; 754–8, 769.

Gladstone, J. H., Ph.D., F.R.S., 17, *Pembridge Square, London*; 579–80.

Glasgow Mechanics' Institution; 451, 460, 497.

Goodman, G. H., 55, *Penrose Street, Newington, S.E.*; 472.

Gordon, J. E. H., B.A., *Gonville and Caius College, Cambridge*; 705.

Gore, G., F.R.S., 50, *Islington Row, Edgbaston, Birmingham*; 163, 256, 285–7, 308–9, 316–7, 323, 325–7, 335, 340, 576–7, 1069–70.

Gossage, W., and Sons, *Widnes, Lancashire*; 652–3.

Grantham, Mrs. J., *Kirkby Cottage, Croydon, Surrey*; 549.

Gray, J. W., and Son, *Mary Street, Rhodeswell Road, Limehouse, London*; 318.

Green, R. and H., *Blackwall, London*; 505–6.

Greenhill, A. G., *Royal Artillery, Woolwich*; 21.

Gregory, J. R., 88, *Charlotte Street, Fitzroy Square, London*; 861, 884, 888, 893, 1042.

Griesbach, Mrs., *Holland Street, Kensington, London*; 197.

Griffin, J. J., and Sons, 22, *Garrick Street, Covent Garden, London*; 1026–34.

Grove, the Hon. Sir W. R., 115, *Harley Street, London*; 304.

Groves, W., 89, *Bolsover Street, London*; 181, 426.

Grubb, H., F.R.A.S., *Dublin*; 400–1, 432.

Guest and Chrimes, *Rotherham*; 80.

Gurney, S., 20, *Hanover Terrace, N.W.*; 814.

Guthrie, Prof. F., Ph.D., F.R.S., *Royal School of Mines, Jermyn Street, London*; 104, 151, 163, 178, 182–3, 190, 275, 280, 282, 298–9, 311, 320, 323, 327, 337, 591, 885, 1006–9.

Hamilton, J., 2, *Granby Terrace, Glasgow*; 491.

Hamilton, J. Baillie, *Greenwich Park*; 200–1.

Hankey, T., 71, *Chester Square, S.W.*; 129.

Harding, A. B., F.P.S., 1, *Albion Villas, Forest Hill, London*; 323.

Harding, T. R., and Son, *Tower Works, Leeds*; 102–3.

Hargreaves, J., *Widnes, Lancashire*; 273.

Hargreaves and Robinson, *Widnes, Lancashire*; 643.

Harrison, W. J., F.G.S., *Curator, Town Museum, Leicester*; 839.

Harvey, Reynolds, & Co., 14, *Commercial Street, Leeds*; 239, 257, 263, 280, 301, 309, 315, 334, 641, 913, 926, 942–3.

Haswell, J., *Sunderland*; 514.

Hathorn & Co., *Sun Foundry, Leeds*; 464.

Hawkins, S. J., 27, *Lichfield Grove, Finchley*; 16, 75.

Hawksley, T., 300, *Oxford Street, London*; 53, 179, 462, 915, 922, 926–7, 931, 933–6, 939, 944, 948–50, 952, 954, 995, 1001.

Hay, R. H., *Sunderland*; 514.

Hayden, W., *Little London, Chichester*; 477.

Head, J., M.I.C.E., *Middlesborough*; 453, 469, 479, 548–9, 667.

Hector, J., C.M.G., M.D., F.R.S., 7, *Westminster Chambers, London*; 830.

Hedges, K. W., & Co., 36, *King William Street, London, E.C.*; 462.

Henderson, D. and W., & Co., *Meadowside Works, Glasgow*; 509–12.

Henderson, R., *Timsbury, Bath*; 762, 873.

Hennessy, Prof. H., F.R.S., *Royal College of Science, Dublin*; 7, 35, 51, 87, 109, 724.

Henrici, Prof. O., F.R.S., *University College, London*; 34, 35.

Hermann, I., 21, *Northampton Square, E.C.*; 125.

Herschel, Prof. A. S., *College of Physical Science, Newcastle-on-Tyne*; 207, 234, 247, 412.

Hicks, J., 8, *Hatton Garden, E.C.*; 171, 680, 689–90, 698, 714.

Higham, A. J., 13, *Blackheath Terrace, London, S.E.*; 118.

Hilger, A., 192, *Tottenham Court Road, London*; 59, 88, 204, 213, 227, 230, 402–3, 405, 438, 763.

Hill, Capt. H., 53, *Marine Parade, Brighton*; 346.

Hirsch, H., 25, *Craven Street, Strand, W.C.*; 525–6.

Hirst, Brooke, and Hirst, *Leeds*; 661.

Hodgkin, Neuhaus, & Co., 61, 63, *Queen Victoria Street, E.C.*; 463.

HOGGAN, G. & F. E., M. D., 13, *Grenville Place, Portman Square*; 977.

HOLMAN, D. S., *Philadelphia, U.S.A.*; 928.

HOLMES, J. M., *Town Hall Chambers, Birmingham*; 549.

HOLMES, N. J., 8, *Gt. Winchester Street Buildings, E.C.*; 534–5.

HOLT, H. P., C.E., *Royal Insurance Buildings, Leeds*; 75, 453, 456, 469, 474, 498.

HOOKER, J. D., M.D., P.R.S., *Royal Gardens, Kew, Surrey*; 112, 904.

HOPKINS & WILLIAMS, 16, *Cross Street, Hatton Garden, E.C.*; 620.

HORNER, C., *Fern Villa, Mortlake, Surrey*; 231.

HOROLOGICAL INSTITUTE, BRITISH, 35, *Northampton Square, London*; 123–5.

HOW, J., & Co., 5, *St. Bride Street, Fleet Street*, late 2, *Foster Lane, London*; 166, 214, 280, 290, 305, 313, 339, 380–1, 629, 839, 884, 907, 916, 979.

HOWE, W., *Clay Cross, Chesterfield*; 146.

HULL, E., DIRECTOR, (*Geological Society of London*); 815–21.

HULL, PROF. E., M.A., F.R.S., *Royal College of Science, Dublin*; 813.

HUNT, R., *Craven Hotel, Strand*; 550.

HUNTER & ENGLISH, *Bow*; 525.

HUSBANDS, H., *Bristol*; 743, 753.

HUTCHINSON, J., & Co., *Windes, Lancashire*; 645–7.

HUXLEY, PROF., F.R.S., *Royal School of Mines, Jermyn Street, London*; 993–4.

HYDRAULIC ENGINEERING Co., *Chester*; 455.

INDIA, SECRETARY OF STATE FOR, *India Office, Whitehall, London*; 729–30, 787–9.

IRELAND, GENERAL VALUATION OF, *Dublin*; 803.

IRELAND, ROYAL COLLEGE OF SCIENCE FOR, *Stephen's Green, Dublin*. (*See* ROYAL COLLEGE OF SCIENCE.)

JACKSON, REV. J. C., 67, *Amherst Road, Hackney, London*; 116, 391.

JACKSON, M., 65, *Barbican, London*; 1009–10.

JEBB, G. R., *Chester*; 553.

JELLETT, REV. J. H., B.D., *Trinity College, Dublin*; 217.

JOHNSON, MATTHEY, & Co., *Hatton Garden, London*; 53, 88, 641, 669.

JOHNSTON, W. & A. K., 18, *Paternoster Row, E.C.*; 1034–5.

JORDAN, J. B., *Museum of Practical Geology, Jermyn Street, London*; 681, 815, 851.

JOULE, J. P., D.C.L., F.R.S., *Broughton, Manchester*; 163, 281, 287, 290.

KEMPE, A. B., B.A., 7, *Crown Office Row, Inner Temple, London*; 145–6.

KESSELMEYER, CH. A., *Manchester*; 439.

KEW COMMITTEE OF THE ROYAL SOCIETY, *Kew Observatory, Surrey*; 212, 261, 291, 293–6, 299, 332–3, 398, 421, 424, 694, 697, 701, 711, 738–9, 768.

KEW MUSEUM, *Royal Gardens, Kew, Surrey*; 982.

KING'S COLLEGE, LONDON, COUNCIL OF, *Somerset House, Strand, London*; 13, 147, 150, 162–3, 166, 202, 204, 223, 237, 258, 283, 301–2, 311, 321, 324, 342, 368–9, 382, 426, 450, 464–5, 479, 529; 547, 553, 702, 1046.

KINGSTON, G. T., *Meteorological Office of the Dominion of Canada; Toronto, Canada*; 695–6.

KNOBEL, E. B., F.R.A.S., F.G.S. 20, *Avenue Road, Regent's Park, London*; 406, 438.

KULLBERG, V., 135, *Liverpool Road, N.*; 127.

LADD, W., & Co., 11 *and* 12, *Beak Street, Regent Street, London*; 223, 224, 313, 909.

LAIDLER, W. H., 9, *Edward Street*; *Bow Common, London*; 60.

LAING, J., *Deptford Yard, Sunderland*; 517.

LAIRD BROTHERS, *Birkenhead Iron Works, Birkenhead*; 500–5, 531.

LASLETT, T. N., 97, *Maryon Road, Charlton, S.E.*; 748.

LATHBURY, R., JUN., *Park House, Chiswick, Middlesex*; 499.

Law, C., *Champion Park, Camberwell, S.E.*; 567.

Lawes, J. B., F.R.S., *Rothamsted, St. Albans*; 661, 662, 994–5.

Lawrence and Porter, 36, *Parliament Street, London*; 464.

Lawton, W., 49, *High Street, Hull*; 412.

Leard, A., M.D., 12, *Old Burlington Street, W.*; 948.

Leckey, R. J., F.R.A.S., *Scientific Club, 7, Saville Row*; 391, 398, 750.

Letts, Dr. E. A., *University of Edinburgh*; 262, 592–7.

Lettsom, W. G., 2, *Thurlow Place, Lower Norwood*; 249.

Ley, H. W., 16, *Bear Street, Leicester Square, London*; 119–21.

Lidstone, T., *Dartmouth, Devon*; 450.

Liggins, H., 3, *Ladbroke Square, W.*; 516.

Lights, Northern, Commissioners of, *Edinburgh*; 536–8, 545–6.

Linnean Society, *Burlington House, London*; 980–2.

Lippincott. *See* Cann-Lippincott.

Literary and Philosophical Society of Manchester; 564–7.

Lloyd, Rev. H., D.D., F.R.S., *Trinity College, Dublin*; 168, 182, 217, 223, 228, 229, 274, 290, 339–40, 386.

Lloyd's Register of British and Foreign Shipping, *Cornhill, London*; 508.

Lockyer, J. Norman, F.R.S., 5, *Alexandra Road, London*; 404, 420, 424–6, 432–34, 717, 814, 1064.

Lockyer, Mrs. Norman, 5, *Alexandra Road, London*; 433.

London, Geological Society of, *Burlington House, Piccadilly, London*; 815–21.

London Institution, *Finsbury Circus, London*; 304.

London Mathematical Society, 22, *Albemarle Street, London*; 30–4.

London Ordnance Co., *Vavasseur Street, Southwark*; 551–2.

London, Zoological Society of, 11, *Hanover Square, London*; 995–7.

Longmans, Messrs., *Paternoster Row, London*; 1068–9.

Lovell, T. M., Inst. C. E. per Garnham and Co., *Wilson Street, Finsbury, London*; 548.

Lowne, R. M., *Leicester House, East End, Finchley, London*; 98–9, 945.

Luvini, Prof., per Meteorological Office, 116, *Victoria Street, S.W.*; 717.

Maclauchlan, J. (Chief Librarian), *Dundee Free Library and Museum*; 203, 476, 479.

McLeod, Prof. H., *Cooper's Hill College, Staines*; 163, 172, 620, 625.

Macmillan & Co., *Bedford Street, Strand*; 1065–8.

McNab, Prof. W. R., M.D., *Royal College of Science, Dublin*; 926, 994.

Maddox, Dr. (*See* How and Co., 5, *St. Bride Street, Fleet Street, E.C., London.*)

Main, Rev. R., F.R.S., Director of the *Radcliffe Observatory, Oxford*; 411, 717.

Major, Dr. H., *West Riding Asylum, Wakefield*; 664.

Makins, G. H., *Danesfield, Walton-on-Thames*; 478.

Mallet, R., C.E., F.R.S., *The Grove, Clapham Road, S.*; 773.

Manchester, Council of the Literary and Philosophical Society of; 564.

Mann, R. J., M.D., 5, *Kingsdown Villas, Wandsworth Common, London*; 323, 337, 425, 805, 839, 1064.

Marratt, J. S., 63, *King William Street, London*; 428.

Marsden, R. S., *University of Edinburgh*; 595.

Marshall, A., *Perseverance Iron Works, Heneage Street, Whitechapel, E.*; 457–8.

Marshall, J., Sons and Co., *Leeds*, 661.

Martin, J., 58, *Arundel Square, London*; 234.

Maskelyne, Prof. N. S., F.R.S., 112, *Gloucester Terrace, Hyde Park, London*; 227, 887, 895.

Massey; E., *Openshaw Works, Manchester*; 95, 770.

Master of the Mint, The, *London*; 665–6.

Mathematical Society, London, 22, *Albemarle Street, London*; 30–4.

Mathieson, N., & Co., *Widnes, Lancashire*; 647–8.

Maudslay, Sons, and Field, *Lambeth, London*; 455, 483–5, 491–2, 518–20.

Maxwell, Prof. Clerk, 11, *Scroope Terrace, Cambridge*; 40, 276, 341–2.

Mayland, W., 236, *Regent Street, London*; 237.

Mechanics' Institution, *Glasgow*; 451, 460, 497.

Menzies and Blagburn, *King Street, Newcastle-upon-Tyne*; 477.

Merrifield, C. W., F.R.S., *Education Department, Whitehall, London*; 813.

Meteorological Committee of the Royal Society, London; 243, 673–6, 698, 705, 711, 721.

Meteorological Office, 116, *Victoria Street, S.W.*; 676, 717–8.

Meteorological Society, 30, *Great George Street, Westminster*; 673–4, 676.

Meteorological Society, Scottish, *General Post Office Buildings, Edinburgh*; 225, 674, 680, 686, 689, 692, 697, 713, 716, 718–20, 723.

Millar, W. J., C.E., 100, *Wellington Street, Glasgow*; 446.

Miller, W. H., M.A., F.R.S., *Professor of Mineralogy, Cambridge*; 126, 767, 886.

Milton, J. L., *Sion House, King's Road, London*; 252.

Mines, Royal School of, *Jermyn Street, London*; 59, 553–62.

Mining and Mechanical Engineers, North of England Institute of, *Newcastle-upon-Tyne*; 876–8.

Mitchell, C., & Co., *Newcastle-on-Tyne*; 508–9.

Mitchell, W. S., LL.B.; 823.

Molineux, T., 8, *Park Village East, Regent's Park*; 193.

Moody, W., 2, *Nightingale Vale, Woolwich, Kent*; 500.

Moon, G. W., 164, *Regent Street, W.*; 685.

Moore, B. T.; *Spring Grove, Isleworth*; 95, 97.

Morison, D. P., 21, *Collingwood Street, Newcastle-upon-Tyne*; 869–70.

Morris Patents Engineering Works, 50, *High Street, Birmingham*; 75–6.

Morrison, R. M., *University of Edinburgh*; 597.

Mottershead & Co., *Manchester*; 321, 1026.

Moy, T.; *Institution of Naval Architects, John St., Adelphi, London*; 524.

Muller, Hugo W., F.R.S.; 303.

Muller, J. A., C.E., 30, *Craven Street, Strand, London*; 96.

Murby, T., 32, *Bouverie Street, E.C.*; 431, 1046.

Murray, Capt. (per F. Buckland); 781.

Murray & Co., *Chester-le-Street, Durham*; 550.

Murray, R. C., 69, *Jermyn Street, London*; 229.

Museum of Science and Art, *Edinburgh*; 220, 257, 285, 347, 563–4.

Muspratt, J., & Sons, *Widnes, Lancashire*; 651–2.

Mylne, R. W., C.E., F.R.S., F.G.S., 21, *Whitehall Place, London*; 828–9.

Napier and Ettrick, Lord, 40, *Queen Anne's Gate*; 7.

Napier, R., *West Shandon, Dumbartonshire, Scotland*; 491, 509.

Nasmyth, J., *Hammerfield, Penshurst, Kent*; 473.

Naval Architects, Institute of, 20, *John Street, Adelphi*; 516, 529.

Naval Museum, Royal, *Greenwich*, 117, 391, 499, 781.

Nesbitt, A., F.S.A., *Oldlands, Uckfield*; 74.

Negretti and Zambra, *Hatton Garden, London*; 675, 677–9, 684, 687–9, 691, 700.

Nelson Dock Co., Limited, 16, *London Street, Rotherhithe, London*; 515.

Newall and Co.; 130, *Strand, London*; 530.

Newton, E. T., *Museum of Practical Geology, Jermyn Street, London*; 978.

Nicholas, J., 90, *Brunswick Street, Manchester*; 67, 467.

Nickoll and Crewe; 36, *St. Mary Axe, London*; 522–3.

Nicol, W. J., *University of Edinburgh*; 595–6.

Norris, W. J., and Brother, *Calder Chemical Works, Sowerby Bridge, Halifax*; 654.

North of England Institute of Mining and Mechanical Engineers, *Newcastle-upon-Tyne*; 876–8.

Northern Lights, Commissioners of, *Edinburgh*; 536–8, 545–6.

Oertling, L., *Turnmill Street, London*; 15, 81, 88, 171.

Olrick, L., 37, *Leadenhall Street, E.C.*; 446.

Ommaney, Admiral, 6, *Talbot Square, Sussex Gardens, W.*; 741.

Ordnance Survey (Maj.-Gen. Cameron, R.E., F.R.S., Director General), *Southampton*; 725–8, 783–5.

Ordnance Survey of Palestine, 9, *Pall Mall East, London*; 786.

O'Reilly, Prof. J. P., *Royal College of Science, Dublin*; 214, 679, 849–50, 879, 885, 888, 894.

Orton, Rev. W. Previté, M.A., *Ornesby, Rugby*; 221.

Oxford, University of; 885–6.

Oxford University Museum, *Oxford*; 840, 844, 983–4.

Palestine, Ordnance Survey of, 9, *Pall Mall East, London*; 786.

Parkes, Mrs., 17, *Wimpole Street, W.*; 208.

Parkinson and Frodsham, 4, *Change Alley, E.C.*; 126, 636.

Pastorelli, F., 208, *Piccadilly, London*; 96, 99, 675, 682, 685–6, 689–90, 694–5, 698, 708, 742, 752, 871–2, 942.

Patents, Commissioners of, *Patent Office Museum, South Kensington, London*; 4, 65, 116, 283, 451–2, 457, 460, 462, 465, 467, 469–72, 477, 480, 491, 498, 529.

Pearson, A. A., 44 *and* 46, *Queen's Place, Leeds*; 438.

Pendred, V., *Streatham Hill, Surrey*; 508.

Perigal, H., F.R.A.S., 9, *North Crescent, Bedford Square, London*; 21, 147–8.

Perkin, W. H., F.R.S., *The Chestnuts, Sudbury, Harrow*; 586–90.

Phorson, P., *Sunderland*; 518.

Pichler, S. F., 162, *Great Portland Street, London*; 178, 196, 250, 475, 530, 916.

Pigot, Prof. T. F., C.E., M.R.I.A., *Royal College of Science, Dublin*; 39, 55, 476, 551.

Pillischer, M., 88, *New Bond Street, London*; 679, 684, 703, 907, 916.

Poole, J., & Co., 33, *Spencer Street, Clerkenwell, London*; 117.

Porter, H., 181, *Strand, London*; 17, 680, 685, 741, 752, 756, 768.

Postmaster-General, H.M., *St. Martin's-le-Grand, London*; 349–61, 550.

Preece, W. H., *General Post Office, London*; 336.

Prestwich, Prof. J., F.R.S., *Oxford*; 844.

Price, W., 181, *Burrage Road, Plumstead*; 656.

Pritchard, Urban, M.D., 41, *Guilford Street, Russell Square, London*; 920.

Prosser, W. H., 108, *South Hill Park, Hampstead*; 5, 477.

Purves, W. L., 7, *Hanover Street, Hanover Square, W.*; 929–30, 933.

Ransomes, Sims, & Head, *Orwell Works, Ipswich*; 454.

Ratti, Aurel de, *Bradford Grammar School*; 303.

Rayleigh, Lord, F.R.S., 4, *Carlton Gardens, London*; 165, 191.

Raynor, W., *Radcliffe, Manchester*; 315.

Read, Mrs., 27, *Sussex Place, South Kensington, London*; 194.

Reid, J., & Co., *Port Glasgow*; 490, 497.

Reid, Brothers, 12, *Wharf Road, City Road, London*; 347–9.

Rennie, J. & G., *Holland Street, Blackfriars, S.E.*; 520–2.

Reynolds, Prof. O., *Owen's College, Manchester*; 39, 108.

Riaño, Señor F., 23*a*, *Connaught Square, W.*; 374.

Richardson, Duck, & Co., *Stockton-on-Tees*; 508.

Richardson, T. & Sons, *Hartlepool*; 522.

Ritchie, J., & Son, 25, *Leith Street, Edinburgh*; 415–9.

Roberts, W. H., *Snodland, Kent*; 781.

Roberts, W. Chandler, F.R.S., *Royal Mint, London*; 208, 568–70.

Roberts, Dale, & Co., *Manchester and Warrington*; 653.

Roscoe, Prof., F.R.S., *Owen's College, Manchester*; 217, 563, 567, 577–9, 644, 670, 705–7.

Ross and Co., 7, *Wigmore Street, Cavendish Square, London*; 239, 905.

Ross, Major W. A., 3, *Mayland Row, Shepherd's Bush*; 638.

Rosse, Earl of, F.R.S., *Birr Castle, Parsonstown, Ireland*; 401, 406, 412, 432, 438.

Round, J., 196, *Camberwell Road, London*; 376.

Rowley, W., C.E., F.G.S., 74, *Albion Street, Leeds*; 874, 879–80.

Royal Agricultural Society of England, 12, *Hanover Square, London*; 474.

Royal Astronomical Society, *Burlington House, Piccadilly, London*; 411, 413.

Royal College of Science for Ireland, *Stephen's Green, Dublin*; 8. *See also* Professors Adams, Barrett, Galloway, Hennessy, Hull, McNab, O'Reilly, and Pigot.

Royal College of Surgeons of England, *Lincoln's Inn Fields, London*; 976.

Royal Commissioners for the International Exhibition, 1851; 724, 814.

Royal Geographical Society of London, 1, *Savile Row, Burlington Gardens, London*; 740, 798–801.

Royal Indian Engineering College, *Cooper's Hill*; 461.

Royal Institution of Great Britain, 21, *Albemarle Street, London*; 257, 286, 302, 381–2, 477, 563, 567–8, 878.

Royal Microscopical Society, *King's College, London*; 475, 902–3.

Royal Museum, Salford, *Peel Park, Salford*; 7, 8, 119, 250, 281, 476–7, 487, 550, 681, 901–2.

Royal Naval Museum, *Greenwich*; 117, 391, 781.

Royal Observatory, *Greenwich*; 129.

Royal Polytechnic Institution, *Regent Street, W.*; 312.

Royal School of Mines, *Jermyn Street, London*; 59, 553–62.

Royal Society, *Burlington House, Piccadilly, London*; 57, 89, 111, 117, 159, 171, 291, 298, 399, 410–11, 413, 421, 431, 690, 699, 738, 741, 750, 875.

Royal United Service Institution, *Whitehall Yard, London*; 115–6, 392.

Royden, T., (*Shipbuilder*) *Liverpool*; 507.

Royston-Pigott, G. W., M.D., F.R.S., *Hartley Court, Reading*, 57, 908, 919.

Rubie, G. P.; 527.

Rücker, Prof. A. W., M.A., *Yorkshire College of Science, Leeds*; 63.

Ruhmkorff, 11, *Beak Street, Regent Street*; 311, 314.

Russian Embassy, The, *Chesham Place, S.W.*; 516.

Rutherford, Prof., *Edinburgh*; 944.

Rutley, F., *Geological Survey Office, Jermyn Street, London*; 826–7.

Rutter, H. L., 1, *St. Barnabas Villas, Lansdowne Circus, South Lambeth, S.W.*; 281, 316.

Rutter, J. O. N., F.R.A.S., *Black Rock, Brighton*; 313.

Sabine, R., 25, *Cumberland Terrace, Regent's Park, London*; 181, 203, 208, 233–4, 244, 348.

Salford Royal Museum, *Peel Park, Salford*; 7, 8, 119, 250, 281, 476–7, 487, 550, 681, 901–2.

Samuda, Brothers, *Poplar*; 522.

Samuelson, B., M.P., *Middlesborough*; 668.

Sanderson, Dr. B., F.R.S., 49 *Queen Anne Street, W.*; 948.

Sanderson and Proctor, *Shore Works, Huddersfield, and* 19 *and* 21, *Queen Victoria Street, London*; 277, 318.

Scherzer, Dr. K. von, *Austrian Consulate General*, 29, *St. Swithin's Lane, London*; 748.

School of Military Engineering, *Chatham*; 237.

Schorlemmer, C., F.R.S., *Owen's College, Manchester*; 591–2.

SCHUNK, DR., *Owen's College, Manchester*; 663.

SCIENCE SCHOOLS, *South Kensington Museum*; 1063.

SCOTLAND, GEOLOGICAL SURVEY OF, *Edinburgh*; 827.

SCOTT-MONCRIEFF, W. D., 9, *Great Queen Street, Westminster*; 468, 489–90.

SCOTT, R. H., F.R.S., *Director, Meteorological Office*, 116, *Victoria Street, Westminster*; 689.

SCOTTISH METEOROLOGICAL SOCIETY, *General Post Office Buildings, Edinburgh*; 225, 674, 680, 686, 689, 692, 697, 713, 716, 718–20, 723.

SECRETARY OF STATE FOR INDIA, *India Office, Whitehall, London*; 729–30, 787–9.

SHAND, MASON, & CO., 75, *Upper Ground Street, London*; 463.

SHARMAN, G., *St. Leonard's Villa, West End Lane, Kilburn, London*; 861.

SHORT, BROTHERS, *Sunderland*; 528–9.

SIEBE AND GORMAN, *Mason Street, Westminster Bridge Road*; 531.

SIEMENS, DR. C. W., *London*; 250, 265–7, 468.

SIMEY, A., & CO., *Sunderland*; 518.

SINCLAIR, J., 104, *Leadenhall Street, London*; 487.

SKERTCHLY, SYDNEY B. J., F.G.S., *Geological Survey, Jermyn Street, London*; 712.

SKINNER, (*Shipbuilder*) *Sunderland*; 518.

SMITH, DEW, 7*a*, *Eaton Square, S.W.*; 950.

SMITH, EDWIN, *Bath*; 411.

SMITH'S INSTITUTE, *Stirling*; 79.

SMITH, LIEUT.-GEN. M. W., 58, *Gloucester Crescent, Hyde Park, W.*; 19.

SMITH, T. AND W., *Newcastle-on-Tyne*; 530.

SMITH, W., C.E., *Newcastle-on-Tyne*; 523–4.

SMITH, W. G., 15, *Mildmay Grove, N.*; 985.

SMYTH, J., JUN., M.I.C.E.I., *Milltown, Banbridge, Ireland*; 714–5.

SMYTH, PROF. PIAZZI, *Royal Observatory, Edinburgh*; 50, 51, 111, 239, 258.

SOCIETY FOR PROMOTING CHRISTIAN KNOWLEDGE, *Lincoln's Inn Fields, W.C.*; 829.

SOMERVILLE, J., 20, *Westland Row, Dublin*; 472.

SORBY, H. C., F.R.S., *Broomfield, Sheffield*; 845–6, 905.

SOUTH KENSINGTON MUSEUM, *London*; 22–30, 129, 193–4, 203, 205, 227, 379, 395, 447–9, 454–5, 458, 464, 465–7, 470, 480–3, 492–7, 532, 546, 782.

SPEECHLY, H., 43, *King's Road, St. Pancras, London*; 194.

SPEKE, W., jun., *Jordans, Ilminster, Somersetshire*; 741.

SPENCE, P., *Pendleton Alum Works, Manchester*; 651.

SPILLER, J., F.C.S., 2, *St. Mary's Rd., Canonbury, London*; 205, 207, 905.

SPOTTISWOODE, W., F.R.S., 50, *Grosvenor Place, London*; 220, 222.

SPOTTISWOODE, MRS. W., 50, *Grosvenor Place, London*; 222.

SPRAGUE, J. T., 315, *Green Lane, Birmingham*; 337.

SPRENGEL, H., 44, *Charlwood Street, Pimlico, London*; 165.

STANDARDS DEPARTMENT, BOARD OF TRADE (H. W. Chisholm, Warden), 7, *Old Palace Yard, London*; 42–7.

STANFORD, E., *Charing Cross, London*; 824, 827–8.

STANLEY, A. AND F. *New Britain*, 35, *Chambers St., New York*; 53.

STANLEY, W. F., 3, *Great Turnstile, Holborn, London*; 17.

STEELE, R. & CO., *Greenock*; 517–8.

STEPHENSON, G. R., *Albemarle Lodge, Wimbledon Park*; 457.

STEPHENSON, J. W., *Equitable Assurance Office, Mansion House Street, London*; 906.

STEVENSON, D. AND T., *Northern Lighthouse Office, Edinburgh*; 546.

STEWART, PROF. BALFOUR, F.R.S., *Owen's College, Manchester*; 243, 276, 692.

STIFF AND SONS, *London Pottery, Lambeth*; 655.

STIRLING, THE BURGH OF, *Stirling*; 55.

STONE, DR. W. H., *Dean's Yard, Westminster*; 153, 166, 181, 183, 193, 196, 207, 246, 281, 287, 298, 300, 426.

Strawson, G. W., 9, *Pancras Lane, London*; 17, 112, 747, 750, 752, 873.

Struthers, Prof., *Aberdeen University*; 937, 979.

Sub-Wealden Exploration Committee (W. Topley, F.G.S., and H. Willett, F.G.S.); 837–9.

Sugg, W., *Vincent Works, Vincent Street, Westminster*; 225, 249.

Sullivan & Co., *British Alkali Works, Widnes, Lancashire*; 642–3.

Sunderland, Corporation of; 518.

Swift, J., 43, *University Street, Tottenham Court Road, London*; 907–8, 917, 927.

Symons, G. J., 62, *Camden Square, London*; 289, 682, 686–7, 698, 700, 702, 717, 720–1, 743.

Tait, Prof. P. G., M.A., *University of Edinburgh*; 275, 310, 321, 324.

Talbot, H. Fox, F.R.S., *Lacock Abbey, Chippenham*; 237.

Tangye Brothers, and Holman, 10, *Laurence Pountney Lane, London*; 454.

Taylor, Major M. L., R.A., *Royal Artillery Institution, Woolwich*; 104, 117, 741.

Teasdale, W., *Headingley, Leeds*; 908.

Tennant, Prof., *Piccadilly, London*; 829.

Thames Iron Works and Shipbuilding Co., *Orchard Yard, Blackwall*; 506, 507.

Thermo-Electric Generator Co., 27, *New Street, Cloth Fair, London*; 310.

Thomas, J. W., *The Laboratory, Cardiff, Wales*; 473, 640.

Thomson, Prof., Jas. *University, Glasgow*; 460–1.

Thomson, Prof. Sir W., F.R.S., *The University, Glasgow*; 11, 12, 49, 50, 152, 321, 329–31, 335–6, 342, 349, 371, 373, 445, 451, 770, 776–9.

Thompson, J. L., and Sons, *Sunderland*; 518.

Thompson, R., Junr., *Sunderland*; 514.

Thorpe, Prof., *Yorkshire College of Science, Leeds*; 217, 653.

Thwaites and Carbutt, *Bradford Yorkshire*; 473, 643–4.

Tisley and Spiller, 172, *Brompton Road, London*; 149, 302–3, 318, 716.

Topley, W., F.G.S., *Geological Survey, Jermyn Street, London*; 815–6.

Tribe, A., 17, *Pembridge Square, London*; 579.

Trinity College, Dublin, *Dublin*. (*See* Jellett and Lloyd.)

Trinity House, London, Corporation of, *Trinity Square, Tower Hill, London*; 532–6.

Troughton and Simms, 138, *Fleet Street, London*; 112, 394, 741.

Turnbull, R., 823.

Turner, B. B., 31, *Haymarket, S.W.*; 239.

Tyler, Hayward & Co., 84, *Upper Whitecross Street, London*; 455, 463.

Tylor, J., and Sons, 2, *Newgate Street, E.C.*; 80.

Tyndall, Prof., F.R.S., 21, *Albemarle Street, London*; 190, 274 287.

United Service Institution, Royal, *Whitehall Yard, London*; 115–6, 392.

University of Edinburgh, *Edinburgh*; 276, 295, 316. 398, 451, 721.

University of Oxford, 885–6.

University of Oxford Museum, *Oxford*; 840, 844, 983–4.

Unwin, Prof. W. C., *Cooper's Hill College, Staines*; 96, 461.

Varley, S. A., *Hatfield, Herts*; 314, 373.

Victoria, the Agent-General of, *Victoria Chambers, S.W.*; 803.

Wallace, J. (Tangye Brothers & Rake), 3, *St. Nicholas Buildings, Newcastle-upon-Tyne*; 633–5.

Walter, J., M.P., 40, *Upper Grosvenor Street, London*; 479.

War Office, *Pall Mall, London*; 56, 379.

Ward, J. Clifton, *Greta Bank Cottage, Keswick*; 823–6.

Ward, W. S., *Denison Hall, Leeds*; 167, 335, 370, 563, 754, 904.

Warden, Muirhead, and Clark, 29, *Regent Street, Westminster, London*; 304, 336–7, 344–6, 368–73, 377.

Warwick, J. A., *Derby*; 348.

Waterhouse, A., 20, *New Cavendish Street, London*; 1070–2.

Watkin, Lieut. H., R.A., 1, *Uxbridge Villa, Paget Road, Shooters Hill, London*; 100.

Watson and Son, 313, *High Holborn, London*; 394, 397, 750, 757.

Waugh, J., 29, *Tyrrell St., Bradford*; 915, 918.

Wear, Commissioners of the River, *Sunderland*; 471.

Webb, F. W., *Locomotive Department, L. and N. W. Railway, Crewe*; 458–9, 547–8.

Wedekind, H., 4, *Great Tower Street, London*; 254, 655.

Westwood, Prof., *Oxford*; 986.

Wheatstone Collection of Physical Apparatus, *King's College, London.* (*See* King's College, *London.*)

Wheatstone, the late Sir C.; 346.

Wheeler, E., 48, *Tollington Road, Holloway, London*; 909, 918.

White, J., 241, *Sauchiehall Street, Glasgow*; 329, 498.

White, J., *Cowes, Isle of Wight*; 498.

Whitwell, T., *Stockton-on-Tees*; 668.

Whitworth, Sir Joseph, F.R.S., & Co., 44, *Chorlton Street, Manchester*; 48–49, 444, 669.

Widnes Metal Co., *West Bank, Widnes, Lancashire*; 648–50.

Williams, J., F.C.S., 16, *Cross Street, Hatton Garden, London*; 263.

Williams, Thomas, and Dower, *Star Chemical Works, Brentford, Middlesex*; 655.

Willis, W., 49, *Palace Grove, Bromley, Kent*; 232, 525, 553.

Wiltshire, Rev. T., M.A., *Secretary, Geological Society, Burlington House, Piccadilly, London*; 852.

Winchester, Corporation of, *Winchester*; 47–8.

Wollaston Collection, *Cavendish Laboratory, Cambridge*; 57, 205.

Wollaston, G. H., 117, *Pembroke Road, Clifton, Bristol*; 183, 205, 567, 885.

Wood, G. S., 20, *Lord Street, Liverpool*; 908.

Wood, J., *Ivy Cottage, Burnley Lane*; 456.

Woodbury Permanent Photographic Printing Co., 157, *Great Portland Street, London*; 232, 240, 470–2, 474, 481, 487, 490, 492.

Woodbury, W. B., *Manor House, South Norwood*; 233, 245, 700.

Woodcroft, Bennet, F.R.S., *Great Seal Patent Office, London*; 8, 17, 83, 97, 279, 451–3, 457–8, 470–2, 474, 480, 487, 490, 492.

Woodward, C. J., *Birmingham and Midland Institute, Birmingham*; 150, 205.

Works, H.M. Office of, *London*; 6, 1002.

Wornum and Sons, 16, *Store Street, London*; 193.

Wortley, Col. Stuart, *Patent Museum, South Kensington, London*; 233.

Wrightson, T., *Sunderland*; 513.

Yeates and Son, 2, *Grafton Street, Dublin*; 181, 189, 214, 265, 311, 339, 400, 694, 698.

Yeo, Prof. Gerald, *King's College, W.C.*; 950.

Young, J., *West Docks, South Shields*; 512–3.

Yorkshire College of Science, Council of, *Leeds*; 5, 75, 153, 176, 653.

Yorkshire Philosophical Society, Council of, *York*; 399.

Zanni, G., 31, *Compton Road, Highbury, and* 1, *James Street, Old Street, City Road, London*; 370, 373, 376–7.

Zoological Society of London, 11, *Hanover Square, London*; 995–7.

AUSTRO-HUNGARIAN EMPIRE.

Arzberger, Prof. F., *Imp. & Royal Technical High School, Brünn*; 639, 770.

Bauer, Prof. Dr. A., *Polytechnic Institute*, 20, *Kamtnerstrasse, Vienna*; 253, 671.

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Ettingshausen, Baron C. von, *Prof. of Botany, University of Gratz*; 852–60.

Exner, Dr. W. F., *Professor of Engineering, High School of Agriculture and Forestry, Vienna*; 475.

Forests, Imp. and Royal Institution for carrying out Experiments relating to (Dr. W. Velten, Physiologist to the Institution), *Vienna*; 993.

Fric, V., *Prague*; 989.

Gonda, Herr Bela, *Magyar, Ovar, Hungary*; 663.

Grohmann, Ed., *Vienna*; 7.

Hantken, Prof. M., *University of Buda-Pest*; 867.

Hopfgartner, Lieut. F. (*Imp. and Royal Navy*), *Vienna*; 769–70.

Imp. and Royal Central Institute of Meteorology and Magnetism, *Vienna*; 119, 705, 712, 717.

Imp. and Royal Maritime Government, *Trieste*; 534.

Institute of Pathology, *University of Vienna* (Prof. S. Stricker, Director); 944.

Jenny, C., *Professor, Imperial and Royal Polytechnic Institute, Vienna*; 445.

Klebs, Dr. E. B., (*Pathological Institute*), *Prague*; 927–8, 999, 1000.

Lang, Prof. V. von, *University of Vienna*; 154.

Miller, F., *Innsbruck*; 751, 759.

Moser, Prof. I., *Director of the Imp. and Royal Chemical Institution for Agricultural Researches, Vienna*; 939, 978–9.

Osnaghi, Prof. F., *Imp. and Royal Central Institute of Meteorology, Hohe Warte, Vienna*; 119, 705, 712, 717.

Pathology, Institute of, *University of Vienna* (Prof. S. Stricker, Director); 944.

Paugger, Dr. F., *Director of the Imp. and Royal Commercial and Nautical Academy, Trieste*; 703–4, 780.

Pfaundler, Dr. L., *Prof. of Physics, University of Innsbruck*; 150, 152–3, 261, 273.

Physiological Institute, *Prague*; 936, 939, 947–8.

Prague, Pathological Institute of the University of (Dr. E. Klebs, Director); 927–8, 999–1000.

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Roesler, Prof. Dr. L., *Director of the Imp. and Royal Experimental Station for the Cultivation of the Vine and Fruits, Klosterneuburg*; 664, 919.

Schlesinger, Prof. J., *High School of Agriculture, Vienna*; 747, 759.

Schoen, Prof. J. G., *Polytechnic Institute, Brünn*; 705.

Schopfleuthner, Dr. F., 9, *Wallenstein Strasse, Vienna*; 529–30, 870.

Streintz, Prof. Dr. H., *University of Gratz*; 60.

Stricker, Prof. S., *University of Vienna* (*Institute of Pathology*); 944.

Szabo, Prof. Dr. J., *University of Buda-Pest*; 867.

Tille, J., Prof., *Bohemian Polytechnic Institute, Prague*; 473.

Tinter, Prof. Dr. W., *Polytechnic Institute, Vienna*; 683, 764–6.

Tilser, Prof. F., *Bohemian Polytechnic Institute, Prague*; 35–36.

Trieste, Imperial and Royal Maritime Government at; 534.

University of Gratz; 60.

University of Vienna, Institute of Pathology; 944.

Velten, Dr. W., *Imp. and Royal Institution for carrying out experiments relating to Forests, Vienna*; 993.

Vienna, Imp. and Royal Central Institute of Meteorology and Magnetism; 119, 705, 712, 717.

Vienna University, Institute of Pathology; 944.

Waltenhofen, Dr. A. von, *Prof. of Physics, German Polytechnic Institution, Prague*; 283.

Zenger, C. W., *Prof. of Physics, Bohemian Polytechnic Institution, Prague*; 89, 209, 225, 318, 403, 423, 427, 929.

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Zmurko, Dr. L., *Prof. of Mathematics, University, and Polytechnic Institute, Lemberg*; 18, 20, 21.

Zulkowsky, Prof. C., *Imp. and Royal Technical High School, Brünn*; 639.

BELGIUM.

Arens, Antoine Marianus, *Rue de Bruxelles, Namur*; 1012.

Bruylants, G., *Laboratory of General Chemistry, University of Louvain*; 592.

Cougnet, J., *Ixelles, Brussels*; 165.

Gérard, A. J., 5, *Place St. Lambert, Liège*; 100, 107–8, 128.

Gochet, Prof. A. M., *Normal School, Carlsbourg, Luxembourg*; 813, 1026.

Henry, L., *Professor of Chemistry, University of Louvain*; 592.

Le Boulengé, Major, 23, *Thier de la Fontaine, Liège*; 56, 100.

Leurs, Lieut.-General, 9, *Rue de la Longue-haie, Brussels*; 100.

Malaise, Prof. C., Member of the Royal Academy of Belgium, *State Agricultural Institute, Gembloux, Province of Namur*; 836.

Martinot, A., *Nismes, Mariembourg*; 1011.

Navez, Lieut. Col., *Schaerbeeth, Brussels.*

Piron, Frère M., *Director of the Normal School, Carlsbourg*; 13, 39.

Renard, A., 11, *Rue des Récollets, Louvain*; 845.

Sacré, E., 30, *Rue Cantersteen, Brussels*; 83.

Schwann, Prof. T., 11, *Quai de l'Université, Liège*; 954–5, 1002.

Simonan and Toovey, *Chaussé de Lille, Tournai*; 236.

Van Rysselberghe, F., *Paymaster, Royal Navy, Antwerp, late Professor at the School of Navigation, Ostend*; 74, 709.

Van Scherpenzeel Thini, J., *Director of Mines*, 34, *Rue Nysten, Liège*; 878, 880.

FRANCE.

Alvergniat Frères, 10, *Rue de la Sorbonne, Paris*; 250, 322, 641.

Auzoux, Dr., 96, *Rue de Vaugirard, Paris*; 982–3.

Baudin, 276, *Rue St. Jacques, Paris*; 171, 723.

Becquerel, M. E., 47, *Rue Cuvier, Paris*; 237, 425.

Berthelot, M., 97, *Boulevard St. Michel, Paris*; 1035.

Biard, M., 10, *Rue Mont Theibord, Paris*; 813.

Bonis, Madame, 18, *Rue Montmartre, Paris*; 317.

Bontemps, *Telegraph Inspector, Paris*; 377.

Bourdon, C., 74, *Rue du Faubourg du Temple, Paris*; 128, 146, 166, 456, 470.

Bourgogne, E., 34, *Rue Cardinal Lemoine, Paris*; 977.

Bréguet, 81, *Boulevard Mont Parnasse, Paris*; 173, 280–1, 306–7, 316, 328, 426, 669, 711, 781, 878.

Cacheleux, 6, *Rue des Vieilles Haudriettes, Paris*; 549.

Carré, E., 24, *Rue d'Assas, Paris*; 166, 299, 328.

Chameroy, 162, *Faubourg St.Martin, Paris*; 83.

Cleuet, 196, *Rue d'Allemagne, Paris*; 469.

College of France, Paris; 147, 182, 222, 255, 258, 268, 312, 327.

Collin & Co., 6, *Rue de l'Ecole de Médecine, Paris*; 945.

Collot, Brothers, *Boulevard de Montrouge, Paris*; 79, 83, 87.

Conservatoire des Arts et Métiers, *Paris*; 3, 12, 21, 128, 162–9, 182, 196, 234, 255, 261, 268, 274, 295, 305, 307, 324, 338, 381, 414, 420, 427, 430, 460, 487, 638, 683, 696, 743, 887.

Crétès, M., 66, *Rue de Rennes, Paris*; 204, 227, 930, 933.

Daubrée, M., Membre de l'Institut, *Director of the School of Mines, Paris*; 847.

D'Abbordre, A., 120, *Rue du Bac, Paris*; 746–7.

Delagrave, M., 58, *Rue des Écoles, Paris*; 813.

Delesse, M., *Chief Engineer of Mines, Paris*; 811–2, 844.

Deleuil, 42, *Rue des Fourneaux, Paris*; 85, 87.

Department of Lighthouses, *France*; 538–45.

Depôt of Marine Charts and Plans, *Paris*; 813.

Deprez, M., 16, *Rue Cassine, Paris*; 370, 467.

Desains, Membre de l'Institut, 78, *Rue d'Arras, Paris*; 274.

Deschiens, 123, *Boulevard St. Michel, Paris*; 372.

Digeon, 13, *Rue de Marseille, Paris*; 153, 446, 476.

Dolfus, E., 9, *Rue St. Fiacre, Paris*; 470.

Duboscq, J., 21, *Rue de l'Odéon, Paris*; 183, 190, 205–6, 215, 218, 240, 250, 328, 337, 420.

Dumoulin-Froment, 85, *Rue Notre Dame des Champs, Paris*; 21, 60, 75, 101, 374, 781.

Dumas, J., 69, *Rue St. Dominique, St. Germain, Paris*; 568.

Eastern Railway of France, *Paris*; 111.

École de Pharmacie, *Rue de l'Arbalète, Paris*; 223.

École Polytechnique, *Paris*; 63, 169, 182, 191, 203, 255, 268, 281, 343, 383.

Enfer Fils, 10, *Rue de Rambouillet, Paris*; 669.

Erhard, 12, *Rue Duguay Trouin, Paris*; 236, 381.

Evrard, 30, *Rue des Blancs Manteaux, Paris*; 413.

Faculty of Sciences, *Paris*; 168, 275.

Feil, 56, *Rue Lebrun, Paris*; 215.

Fizeau, M., Membre de l'Institut, 3, *Rue de la Vieille Estrapade, Paris*; 234, 237.

Fontoure, H., 92, *Rue St. Georges, Paris*; 314.

Fortin Hermann, MM., 122, *Boulevard Mont Parnasse, Paris*; 56, 66, 458.

French Commission for Observing the Transit of Venus in 1874; 413, 423.

Gavard, A., 70, *Quai des Orfèvres, Paris*; 16, 21.

Gillot, *Madame*, 179, *Rue du Faubourg, St. Martin, Paris*; 234.

Girard, A., *Prof., Conservatoire des Arts et Métiers*, 292, *Rue St. Martin, Paris*; 918.

Golaz, 24, *Rue des Fosses, St. Jacques, Paris*; 169, 268–72, 620–3, 625–6.

Gondolo & Co. (misprinted Tondola), 9, *Boulevard du Palais, Paris*; 129.

Goupil & Co., 9, *Rue Chaptal, Paris*; 234.

Gros, 94, *Rue de Montreuil, Paris*; 467.

Guéroult, G., 2, *Rue de Vienne, Paris*; 192.

Guyot D'Arlincourt, 102, *Rue Neuve des Mathurins, Paris*; 373–4.

Hanicque De St. Senoch, 19, *Rue Demours, Paris*; 810.

Hayaux du Tilly, 15, *Rue de Lisbonne, Paris*; 803, 813.

Hirn, G. A., 3, *Logelbach, Colmar*; 110.

Honzeau, M., *Rouen*; 663.

Isoard Fils, 78, *Rue St. Maur, Paris*; 59.

Jamin, 24, *Rue Soufflot, Paris*; 280.

Jannettaz, 9, *Rue Linne, Paris*; 275–6.

Janssen, M., Membre de l'Institut, 33, *Rue Labat, Paris*; 423.

Kastner, F., 43, *Rue de Clichy, Paris*; 179.

Laboratoire du Collége de France, *Place Cambrai, Paris*; 590.

Lancelot, 11, *Rue des Poitevins, Paris*; 196.

Larrey, Baron, 91, *Rue de Lille, Paris*; 927.

Launay, Prof., *Lycée, Caen*; 802.

Laurent, Leon, 21, *Rue de l'Odéon, Paris*; 214, 218, 221, 223, 226, 248, 255, 277, 391, 412, 914–5.

Laussedat, Col., Prof., *Conservatoire des Arts et Métiers, Paris*; 768.

Lemaire Douchy, 64, *Rue Taitbout, Paris*; 879.

Letellier; 90, *Rue Chateau Landon*; 1043.

Loiseau Fils, 29, *Rue Richelieu, Paris*; 166, 282–3, 311.

Luizard, 43, *Rue St. André des Arts, Paris*; 166, 250, 337.

Lutz, M., *Paris*; 117, 122, 204–5, 215, 218, 219, 221, 223, 226–30, 250, 438, 886, 916.

Malligand Fils, 1, *Boulevard St. Michel, Paris*; 663.

Mannheim, Prof., *Ecole Polytechnique, Paris*; 3.

Mariais, 260, *Rue St. Honoré, Paris*; 376.

Marey, Prof. (*College of France*), 13, *Rue Dugay Trouin, Paris*; 970–5.

Mascart, Prof. (*College of France*), *Paris*; 230.

Mathieu, M. L., 16, *Carrefour de l'Odéon, Paris*; 955–6.

Mercadier, M., *Ecole Polytechnique, Paris*; 189.

Molteni, J. **and** A., 44, *Rue du Chateau d'Eau, Paris*; 39, 226, 430, 438, 750.

Mouret, 8, *Cour des Petites Ecuriés* (*Redier*), *Paris*; 428.

Nachet, A., 17, *Rue St. Séverin, Paris*; 205, 911, 930, 934, 936, 945.

Orsat, M., 29, *Rue de la Victoire, Paris*; 657.

Paris Observatory; 215, 247, 398, 420.

Paris, Vice-Admiral, *President de l'Académie des Sciences, Paris*; 498.

Phares de France, Service des, *Place du Trocadéro, Paris*; 538–45.

Picart, A., 20, *Rue Mayet, Paris*; 909, 914.

Polytechnic School, *Paris*; 63, 169, 182, 191, 203, 230, 255, 268, 281, 343, 383.

Redier, *Rue des Petites Ecuries, Paris*; 128, 328, 682, 712.

Renaud-Tachet, MM., 17, *Rue Richelieu, Paris*; 4, 15, 17, 21.

Richard, M., *Paris*; 683.

Roulot, 3, *Rue des Vielles Haudriettes, Paris*; 929–31, 934.

Ruhmkorff, 15, *Rue Champollion, Paris*; 261, 300, 950.

Sautter, Lemonnier et Cie., 26, *Avenue de Souffren, Paris*; 538.

Schloesing, M., 27, *Quai d'Orsay, Paris*; 638.

School of Pharmacy, *Paris*; 223.

Sciences, Faculté des, *Paris*; 168, 275.

Séguier, M. **le**, 3, *Rue du Régard, Paris*; 86, 457, 492, 499, 550.

Service des Phares de France (Lighthouse Service of France), *Place du Trocadéro, Paris*; 538–45.

Société de l'Alliance, La, 25, *Rue Dufrenoy, Paris*; 313–4.

Société Française de Photographie, 20, *Rue Louis le Grand, Paris*; 234, 237.

Tavernier Gravet, 39, *Rue de Babylone, Paris*; 3, 56, 752.

Telegraph Department, *Paris*; 375.

Thiel, Ainé, 75 & 77, *Rue Lacondamine, Paris*; 235–6.

Tramond, 9, *Rue de l'Ecole de Médecine, Paris*; 997–8.

Trouvé, G., 6, *Rue Thérèse, Paris*; 147, 283, 377, 380, 951–2.

Vidal, L., 13, *Quai Voltaire, Paris*; 233, 237.

Villarceau, Y., *Membre de l'Institut*, 18, *Avenue de l'Observatoire, Paris*; 128.

Wentzel, Madame, 6, *Rue Bretonviller, Paris*; 39.

Werlein, 38, *Rue d'Ulm, Paris*; 887–8, 936.

Wiesnegg, 64, *Rue Gay Lussac, Paris*; 636.

Winnerel, M., 35, *Galerie Montpensier* (*Gabriel*), *Paris*; 104, 127.

GERMANY.

Academy of Mines, Royal (Prof. Hauchecorne, Director), *Berlin*; 452–3, 485–6, 835.

Academy of Mines, Royal (Prof. Richter, Director), *Freiberg, Saxony*; 172, 472, 657, 849, 870, 874, 884–5, 894, 897.

Admiralty, Imperial, Hydrographic Department and Nautical Observatory, *Berlin and*

Hamburg; 259, 293, 681, 712, 721–2, 802.

ALBERT, J. W., 34, *Neue Mainzer, strasse, Frankfort-on-Maine*; 188, 206, 218, 245.

ALBRECHT, *Tübingen*; 180, 189, 896.

ALTHAUS, E., *Superintendent of Mines, Breslau*; 277.

ANATOMICAL INSTITUTE (Prof. Dr. B. Gerlach), *Erlangen*; 991–2.

APEL, W., *Göttingen*; 219, 713, 897.

APPUHN, G., AND SONS, *Hanau*; 198–9.

ASSOCIATION FOR THE MANUFACTURE OF ANILINE, *Rummelsburg, near Berlin*; 598.

AUGUST, DR. F., *Humboldt-Gymnasium, Berlin*; 436–7.

BABO, PROF. von (Chemical Laboratory), *Freiburg, Breisgau*; 182.

BACH, DR. O., *Leipzig*; 637.

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Boogaard, Prof. Dr. J. A., *Director of the Museum of Anatomy, Academy of Leyden*; 900.
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Brondgeest, Dr., *Physiological Laboratory and Ophthalmological School, Utrecht*; 958.
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De Loos, Dr. D., *Director of the Secondary Town School, Leyden*; 259, 671.
Donders, Prof., *Physiological Laboratory and Ophthalmological School, Utrecht*; 178, 318, 957–60, 962–70.
Engelmann, Prof., *Physiological Laboratory and Ophthalmological School, Utrecht*; 167, 317, 957, 959–60.
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Snellen, Dr., *Physiological Laboratory and Ophthalmological School, Utrecht*; 748, 961–2, 964–5, 967.
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Van Ankum, Prof. U. J., *Zoological Laboratory, University of Groningen*; 1002.

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Albini, Prof. G., *Director of the Physiological Institute, Royal University of Naples*; 949.

Blaserna, Prof., *Director of the Institute of Physical Science, Royal University of Rome*; 1073–4.

Cacciatore, Prof. G., *Director of the Royal University, Palermo*; 1083.

Cantoni, Prof. G., *Director of the Institute of Physical Science, University of Pavia*; 1082–3.

Cecchi, Prof. F., (*L. Pelli & Co.*), 12, *Viale Militare, Florence*; 299, 389–90.

Collegio Romano (Observatory), *Rome*; 405, 709.

Felici, R., *Director of the University of Pisa*; 1084.

Florence, Royal Institute "di Studii Superiori" (Sig. Peruzzi, President); 16, 77, 113–5, 256, 276, 279, 307, 312, 334, 393, 397, 403, 407–10, 431, 437, 439, 703, 780, 900–1.

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Padua, Royal University of; 1074–8.

Palmieri, Prof., *Director of the Vesuvian and Meteorological Observatory, Naples*; 1084.

Pavia, University of; 1082–3.

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Peruzzi, Sig., *President of the Royal Institute "di Studii Superiori," Florence*; 16, 113, 115, 256, 276, 279, 307, 312, 334, 393, 397, 403, 407–10, 431, 439, 703, 780, 900–1.

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Royal Institute "di Studii Superiori," *Florence* (Sig. Peruzzi, President). (*See* Florence, Royal Institute.)

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Royal University, Modena (Observatory); 1083.

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Royal University of Naples, Physiological Institute (Prof. G. Albini, Director); 949.

Royal University of Padua, Cabinet of Geodesy and Hydrometry (Prof. Legnazzi, Director); 1074–8.

Royal University of Padua, Cabinet of Physical Science (Prof. Rossetti, Director); 1078–82.

Royal Observatory of Palermo (Prof. G. Cacciatore, Director); 1083.

Royal Observatory of the Campidoglio (Prof. L. Respighi, Director), *Rome*; 394, 405.

Royal University of Rome, Institute of Physical Science (Prof. Blaserna, Director); 1073–4.

Secchi, Padre, *Director of the Observatory of the Collegio Romano, Rome*; 405, 709.

Taranelli, T., *Prof. of Physical and Natural Science, Technical School, Udine*; 832.

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Esmark, L., *Prof. of Zoology, University of Christiania*; 1002.

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Czechovicz, C., *Gymnasium of Belostok*; 231, 1010–11.

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Ovsiannikow, Ph., M. Acad. Sc., *Professor of Physiology, University St. Petersburg*; 984–5, 991.

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COMISION DEL MAPA GEOLOGICO DE ESPAÑA, 23, *Calle de Isabel la Catolica, Madrid*; 832–4.

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Studer, Prof. B., *Commission of Switzerland, Geological Survey, Berne*; 829.

Wartmann, E., *Professor of Natural Philosophy, University of Geneva*; 273, 327–8, 370–1.

Wolf, Prof. R., *Director of the Observatory, Zurich*; 722.

UNIVERSITY OF CALIFORNIA

CATALOGUE.

SECTION 1.—ARITHMETIC.

WEST GALLERY, GROUND FLOOR, ROOM G.

I.—SLIDE RULES.

1. Slide Rule, of boxwood, arranged by Mr. Dixon, Lowmoor Ironworks. *Aston & Mander.*

In addition to the lines of the ordinary slide rule this instrument contains :
Lines of common and hyperbolic logs and numbers.
Lines of sines, cosines, and numbers.
Lines of cubes and roots, direct.
A copy of Dixon's " Slide Rule Practice " is issued with each rule.

2. Slide Rule, of ivory, showing the actual and racing tonnage of yachts. *Aston & Mander.*

The length and breadth of beam being " set together," as directed in the instructions, the racing tonnage of yachts of any size is shown as marked.

3. Slide Rule, of boxwood, adapted to brickwork measurement in all its branches, cubing stone, &c. *Aston & Mander.*

In this adaptation of the rule to brickwork measurements, all the results are obtained by one setting, viz., " length to height " ; while, immediately opposite, any thickness will be found ; the superficial area in square feet ; the contents in rods of reduced work 1½ bricks, in cubic feet, in cubic yards, and the number of bricks required.

4. Slide Rule, of boxwood, adapted to timber measurement in all its branches, giving the superficial or cubic contents of round and unequal sided timber, St. Petersburg standard, price, &c. *Aston & Mander.*

5. Slide Rule, of boxwood, with reversible slides, movable inverted lines, &c. Arranged by Chas. Hoare. *Aston & Mander.*

Uses explained in Hoare's " A. B. C. of Slide Rule Practice."

6. Slide Rule, of ivory, with reversible slides, movable inverted lines, &c. Arranged by Chas. Hoare. *Aston & Mander.*

Uses explained in Hoare's " A. B. C. of Slide Rule Practice."

7. Slide Rule, of ivory, adapted for use in iron and steel plate and sheet rolling mills. Designed by Chas. Hoare.

Aston & Mander.

This rule will show directly the precise net and waste weight of iron and steel plates, and sheets, of any size, shape, and thickness. It may be applied to all ordinary metals, and to find areas, cubic contents, liquid capacity, &c.

8. Slide Rule, of boxwood, adapted for sheet iron and steel manufacturers. The dimensions, thicknesses, and weights are given both in English and metrical standards. Designed by Chas. Hoare. *Aston & Mander.*

The length of the sheet or plate (on the slide) being first set to the width, then immediately below any thickness (on the top lines) will be found (on the slide) the actual weight of the sheet either in pounds (avoirdupois) or kilogrammes, metrical or English measures being used without previous conversion.

9. Slide Rule, of ivory, adapted for use in iron and steel-bar rolling mills, showing instantly the precise net and waste weights for bars of any length, size, and form. Designed by Chas. Hoare.

Aston & Mander.

24. Scales, of boxwood, to show cubes, squares, and roots, areas, diameters, circumferences, and decimal equivalents. Designed by Chas. Hoare. *Aston & Mander.*

The bevel edged set square is used to read the divisions, and dispenses with the need of voluminous printed tables.

9a. Three Slide Rules. *Elliott Brothers.*

10. Estimator. A slide rule, by which the volume of prismoidal bodies (embankments, ditches, cuttings, &c., occurring in the construction of railroads, canals, fortifications, &c.,) is calculated mechanically.

Dr. F. M. Stapff, Geological and Mining Engineer at the St. Gotthard Railway.

This instrument, invented by the exhibitor, is patented in Sweden and the United States of America.

11a. Timber Rule, for finding the content of timber of any form, regular or irregular. The rule has eight gauge points or divisors for reducing dimensions in inches to contents in square feet. *Dring and Fage.*

11b. "Verie" or Excise Officer's Rule.

Dring and Fage.

Verie is probably a corruption of "Vero," a revenue officer who made an alteration in the method of laying down some of the lines on the rule; previously to which they were called Everard's rules.

The lines on the rule are the A, B, C, D, MD, (or malt depth) 6x or variety lines, viz., 1st, 2nd, 3rd, 4th, Dr. Hutton's and Dr. Young's, and two ullage lines (segment standing and segment lying).

The A, B, C, and D lines are commonly called Gunter's lines (from Gunter, the celebrated mathematician, who was the first to apply a logarithmic line to the instrument for the solution of arithmetical problems) of which the A, B, and C, are merely repetitions of each, and laid down to single radius, and the D to double radius.

The MD line is similar to the A, B, and C, but is a broken line of two radii, with the figures and divisions in an inverted order (reading from right to left), commencing at 2218·192 in the right-hand radius, and ending at the same point in the left-hand radius, 2218·192 being the number of inches in a bushel. By the method in which this line is arranged and used in conjunction with the A, B, and C lines the contents in bushels of rectangular and similar figures may be found at one operation.

The X or variety lines or lines of special gauge points (invented by Mr. Woolgar) for finding the mean diameter of a cask whatever its form; these lines commence at 18·789, the circular gauge point, and are extended according to each variety to which they may be applied.

The ullage lines are rules for finding the contents of a cask by comparison with a standard cask holding 100 gallons, a form nearest those frequently occurring in practice.

It cannot be ascertained by whom these lines were invented.

The fixed gauge points on the rule are those for the imperial gallon and bushel, both square and round.

These rules are principally used by excise officers and maltsters. So admirable is the arrangement, that nearly every problem to which the principle of the slide rule is applicable can be solved on one of these rules.

11c. Slide Rule, invented by Mr. Coulson, of Redan, used for setting out railway curves, finding the weights of materials from their specific gravities, breaking strains, &c.

Dring and Fage.

The applications of this rule are so varied that the author's description of them exceeds 400 octavo pages of closely printed matter.

12. Slide Rule, by M. Mabire.

Conservatoire des Arts et Métiers, Paris.

12a. Cylindrical Reckoning Rule. (The property of the Conservatoire des Arts et Métiers.)

M. Mannheim, Professor at the Polytechnic School, Paris.

13. Calculating Rules, 1 of 50 cm., 1 of 36 cm., 1 of 26 cm., as arranged by M. Mannheim.

M. Tavernier Gravet, Paris.

13a. Small Cylindrical Calculating Machine. Arranged by M. Mannheim. *Conservatoire des Arts et Métiers, Paris.*

14. Pocket Calculator, arranged by Major-General A. De Lisle, R.E., for the use of engineers. *Elliott Brothers.*

This slide rule is useful for finding the weight of various materials, with the help of the small tables on the back, for checking bills of quantities, and for all approximate calculations required in engineering practice. The slides are:—

On Face.

On Stock—A. The ordinary logarithmic line.
I. The same inverted.
On Slides—Upper I. Inverted line.
" D. Line of squares.
Lower B. Ordinary logarithmic lines.
Tan } Trigonometric lines.
Sin }

Special Marks—
M. Modulus of logs. to find prop. parts of logs.
A. Reciprocal of M. to find hyperbolic logs.
S″ To find length of arcs, &c.
R′ Radius for minutes.
R″ Radius for seconds.

On Back.

On Stock—D. Line of squares.
On Slide—E. Line of cubes read with D on line of $\frac{3}{2}$ powers read with A.
F. Line of $\frac{5}{2}$ powers read with D, or of $\frac{5}{4}$ powers read with A.
Tables and useful Numbers.

Line E with A gives variation in depth of water running over weir due to alteration of length of weir. Neville's Hydraulics, page 22, 3rd edition.

A	$143=d$	
E	$220=l$	$60=l'$
A		$6=d$

Line F with D assists in finding the dimensions of a pipe or channel, with a given hydraulic inclination to discharge a given quantity from the calculated discharge of a pipe or channel of known dimensions and the same inclination. Thus, if a pipe 4″ diameter discharge 15 cubic feet per minute, what diameter will discharge 33 cubic feet? Neville's Hydraulics, page 245.

D		
F	$15=D$	$33=D'$
D	$4=d$	$5.48=d'$

The two slides on the face working together solve the following equations:—

$$x=\frac{ab}{cde};\ x=\frac{abc}{de};\ x=\frac{abcd}{e}$$

15. Slide Rule, of boxwood, with double slide.

Renaud-Tachet, Paris.

16. Routledge's Original Engineers' Slide Rule and manuscript book of instructions for using it.

H. M. Commissioners of Patents.

17. Kentish's Compound Slide Rule.

Dring and Fage.

This is a new and ingenious arrangement of Gunter's lines, by means of which problems in trigonometry and navigation can be solved, in addition to those ordinarily done on the slide rule.

17a. Dr. Roget's Slide Rule of Involution.

W. H. Prosser.

This rule exhibits at one view all the powers and roots of any given number. It is a measure of the powers of numbers, in the same way as Gunter's scale is a measure of their ratios. Described in Phil. Trans. 1815, Part 1.

17b. Slide Rules (3), with double sliders, being suggested improvements on the ordinary slide rule, giving greater clearness in reading off, and avoiding complication in the lines.

W. H. Prosser.

17c. Glass Slide Rule, invented by Léon Lalanne.

W. H. Prosser.

This rule is made of two slips of card, upon which the scales are printed. The slider, also made of card, has scales, constants, and gauge points printed on both sides, and moves between the two slips. The whole is enclosed between two pieces of glass.

17d. Slide Rule, with only one slider, adapted for the pocket-book. Arranged by J. W. Woollgar. *W. H. Prosser.*

18. Salleron's Slide Rule for reduction of volumes of gases to standard temperature and pressure.

The Council of the Yorkshire College of Science.

19. Salleron's Slide Rule for reducing barometric heights to standard temperature.

The Council of the Yorkshire College of Science.

II.—CALCULATING MACHINES.

20. Calculating Machine, adapted to trigonometrical computations, invented by Sir Samuel Morland (1625–1695), and constructed by Henry Sutton and Samuel Knibbs of London, in 1664. Formerly belonging to Mr. C. Babbage, F.R.S.

Major-General Babbage.

On the lid of this machine is the following inscription :

" Machina Cyclologica Trigonometrice Quâ Tribus datis, reliqua omnia in Triangulis Planis Quæsita faciliter atque unico intuitu expediuntur—a Samuele Morlando inventa—Anno Salutis MDCLXIII.

21. Calculating Machine, designed by Viscount Mahon, afterwards third Earl Stanhope (1753–1816), and constructed by James Bullock in 1775. Formerly belonging to Mr. C. Babbage, F.R.S. *Major-General Babbage.*

22. Calculating Machine, designed by Viscount Mahon, afterwards third Earl Stanhope (1753–1816), and constructed by James Bullock in 1777. Formerly belonging to Mr. C. Babbage, F.R.S. *Major-General Babbage.*

23. Babbage's Calculating Machine; or Difference Engine. *H.M. Board of Works.*

This machine was invented by the late Mr. Charles Babbage, F.R.S., who was born on the 26th December 1791, and died on the 18th October 1871.

Its construction was commenced in 1823 by authority, and at the cost of the Government, and was carried on for several years under Mr. Babbage's gratuitous supervision. The work was suspended in 1833, and after many delays, Mr. Babbage was informed in November 1842 that the Government regretted the necessity of abandoning the machine, alleging the expense of its completion as the ground for their decision.

At the time of its suspension about 17,000*l.* had been expended by Government upon its construction, and a large part of the machinery had been made. The small portion now exhibited was put ogether in 1833, prior to the suspension of the work, in order to show the action of the machinery.

The whole engine, when completed, was intended to have had 20 places of figures and 6 orders of differences.

This machine was expressly designed for the purpose of calculating and printing tables, and not to perform single arithmetical sums.

If a single article is wanted, it is not, generally speaking, worth while to construct a machine to make it; but, when large numbers are required, their production comes within the true province of machinery, and in this sense the Difference Engine is emphatically a machine for manufacturing tables.

The mode in which the Difference Engine calculates tables is, by the continual repetition of the simultaneous addition of several columns of figures to other columns, in the manner more particularly described below, and printing the result.

In the small portion put together, and now exhibited, the figure opposite the index on the lowest wheel visible, in all cases, represents units; the figure on the next wheel above, tens; that on the one above it, hundreds; the next thousands, and so on.

The right hand column of wheels shows the result of the calculation or the tabular number; for instance, series of squares, cubes, or logarithms, &c. appear upon it, according to the nature of the calculation the machine is making.

The next or central column represents the First Difference, and the left hand column the Second Difference. At the bottom of the central column is a figure wheel, covered, which can be used as a third difference, so as to enable this portion of the machine to calculate tables of which the Third Difference does not exceed 9. This will be better understood if this last wheel is supposed to represent the lowest wheel of a fourth column of figures standing beyond the left hand side of the machine, as it would be if it formed part of the complete machine.

This arrangement is effected by a movable platform, with axles, and gearing wheels upon them, which are used for adding from the third difference wheel at the bottom of the central column to the second difference which is shown on the left hand column. The effects capable of being produced by this mechanism, when the gearing is altered, and the loose wheels belonging to it are put into gear with certain figure wheels, is explained in Babbage's Ninth Bridgewater Treatise, together with the new views which it opened up to him upon the subject of natural laws.

The three upper wheels of the left hand column are separated from the rest of the machine, and are employed in counting the natural numbers. In other words, they register the number of calculations made by the machine, and give the natural numbers corresponding with the respective terms of the table.

Four half turns of the handle, two backwards and two forwards, are required for each calculation, and the words "calculation complete" come round upon a wheel at the top of the central column to show when this is done. This wheel also shows, by the word "adjust," in what position of the handle the figure wheels may be freely moved by hand, in order to introduce different numbers or a different table.

24b. Cabinet, containing tablets for making mathematical calculations. *Archæological Museum, Madrid.*

Rose wood cabinet, inlaid with ivory. In three divisions are thirty small drawers, containing ivory plates with numbers and divisions for making mathematical calculations. In the inside are the arms of the monastery of the Escorial. Milanese work of the 16th century.

25. Panometer, or Calculating Machine.
Edward Grohmann, Vienna.

By this extremely simple apparatus, various arithmetical computations can be performed with great readiness.

25a. Calculating Machine for Multiplication.
P. Nicholas Dadiane, St. Petersburg.

26. Calculating Machine, for performing complex arithmetical operations; invented by M. Thomas of Colmar.
Professor Hennessy, F.R.S.

26a. Calculating Machine for Adding, Subtracting, Multiplying, and Dividing.
Theodore Esersky, St. Petersburg.

26b. Small Calculating Machine, encased in a pocket-book. *Theodore Esersky, St. Petersburg.*

26c. Ten Copies of Multiplication and Division Tables.
Theodore Esersky, St. Petersburg.

27. Wertheimber's Calculating Machine, applicable to wheel work. Patent, No. 9616—1843.
The Committee, Royal Museum, Peel Park, Salford.

28b. Original Calculating Machine, known as "Napier's Bones." *Lord Napier and Ettrick.*

One of the earliest attempts to construct a calculating machine, made by John Napier, the inventor of logarithms. His method of calculating by rods was published in a volume (which is exhibited with the machine) at Edinburgh in 1617. The apparatus was commonly known as "Napier's Bones."

28. "Napier's Bones" or Rods. Made about 1700.
Dring and Fage.

Invented by Baron Napier, the originator of logarithms, used for performing division and multiplication.

28a. Set of "Napier's Bones." 16th century.
Lewis Evans.

29. Calculating Disc, size about 18 centimeters, with double divided circle; constructed on the system of Prof. Sonne.
Landsberg and Wolpers, Hanover.

30. Calculating Disc, with index of logarithms.
Landsberg and Wolpers, Hanover.

31. Calculating Disc, pocket apparatus.
Landsberg and Wolpers, Hanover.

32. Calculating Circle, 0·08 meter in diameter, with single scale of brass. *Rudolf Weber, Aschaffenburg.*

33. Calculating Circle, 0·15 meter in diameter, with single square and cubic scale. *Rudolf Weber, Aschaffenburg.*

The circles are on account of their continuous scale more convenient and more accurate than straight slide rules. They are, therefore, peculiarly adapted as pocket instruments for practical purposes, and can be relied on to be as accurate as logarithms to four places.

34. Cubing Circle, 0·08 meter in diameter, for ascertaining the cubical contents of trees in forests.
Rudolf Weber, Aschaffenburg.

The cubing circle is to be noted as giving the index numbers for obtaining the cubical contents of *standing* (not felled) timber; these have been obtained from practical experiments carried out by the Government Department of Forests in Bavaria on more than 40,000 trunks of different kinds of trees. The circle may be relied on for great accuracy in forest valuation.

35. Calculating Instrument, invented by Sir S. Morland.
Bennet Woodcroft, F.R.S.

35a. Calculating Planisphere.
Royal College of Science for Ireland, Dublin.

35b. McFarlane's Calculating Planisphere.
The Committee, Royal Museum, Peel Park, Salford.

36. Calculating Machine, designed by the Vicar Hahn of Echterdingen, in 1770-1776; constructed by his son, Court Mechanician in Stuttgart, in 1809; fourth specimen.
Her Highness the Duchess of Urach.

The machine which is exhibited is on exactly the same principle as that of the one now in general use which was invented by Thomas, the only difference being that in Thomas's machine the numbers are placed in straight lines, and in that of Hahn in a circle. It must have served as a model for the machine of Thomas. The machine is to the present day in perfect order, and works calculations up to numbers of 12 digits.

37. Logarithmic Calculation Apparatus, with *one* folding scale, equivalent to five meters in length.

Prof. Gustav Hermann, Aix-la-Chapelle.

Calculation by means of this instrument is effected with the use of only one scale. The two revolving arms are used like a compass. When the logarithm of a quotient $\frac{a}{b}$ has been fixed between the arms, the plate must be turned until the one arm is brought to a factor *c*, the product $\frac{a}{b} c$ will then be read on the other arm. This arrangement admits of the scale being made as long as may be necessary by breaking it into lengths, without rendering the instrument inconvenient. In the exhibited instrument ten circles are used, by which means the scale attains a length of five meters, and is accurate up to $\frac{1}{10000}$. In using the instrument care must be taken to mark the number of each scale circle, which can be fixed by small sliding buttons. The number of the circle on which the result is to be read is found by the same rules as the characteristic of a logarithm, on the supposition that the ten scale-circles form a graphic table of logarithms of all the natural numbers, the base of the system being $\sqrt[10]{10}$.

38. Arithmetical Disc, a very simple calculating machine, with accompanying description. *Prof. Prestel, Emden.*

39. Calculating Machine, of the last century.

The Royal Gewerbe Academy, Berlin (Director, Prof. Reuleaux).

This calculating machine formed part of the legacy of Hofrath Beireis, the well-known physicist and chemist in the 18th century, and is very similar to the calculating machine, No. **36**. The following description which accompanies this calculating machine is especially interesting, as it was probably drawn up and written by the maker.

On the Use of the Calculating Machine.

There are on the small number-discs [Zahlen-Scheiblein] in the smallest [circles], as well as on the large, in the great circles, the numbers 1, 10, 100, 1,000, and so on; these indicate that the numerals on the first disc, where the (1) is marked, are units, on the second disc, where the numeral (10) is marked, the tenfold of the numbers, and on the third, the hundredfold, and so on; and this applies also to those arcs on the largest circles. And if on its first six discs respectively the following numerals were placed, 357,862, they would indicate multiples of the numbers 1, 10, 100, which are on the respective discs. On the sixth disc, where the numeral (3) is placed, is to be found the number 100,000; thus indicating three times a hundred thousand. On the fifth disc the numeral 5 represents 50,000, similarly the numeral 7, 7,000, and so on; this would, in the first place, be "*ciphering*."

Now follows, in the second place, *addition*. In calculating use is made of the same numbers that are placed in the openings on the number disc, the black numbers on the large discs are used for addition and multiplication, and at the commencement noughts must be placed in all the apertures. As an example, the following numbers will now be added together.

352
643
574
―――
1,569

These numbers must be placed on those arcs which are found consecutively in the outer circle. The handle must then be turned, when the numerals 352 will have come in the place of the noughts, on the three first large discs under the opening. Then the second and third row are placed on the discs and by turning the handle added to the preceding.

In the third place comes subtraction, and it must first of all be understood that the red numbers are to be used on the larger discs; for the rest the method is very easy.

The following is an example:—

$$\begin{array}{r} 5,786 \\ 3,524 \\ \hline 2,262 \\ \hline\hline \end{array}$$

The numbers 5,786, as the larger numbers are placed in red figures in the openings of the large discs; (6) in the units, (8) in the tens, and so on. The smaller number, which is to be subtracted, must be placed on the arcs, in the same order as was shown for addition. And in the same manner likewise must the handle be turned round *once*, and then all is done, and the remainder appears in the openings in which the larger amount was previously to be seen.

$$\begin{array}{r} 365 \\ 24 \\ \hline 1,460 \\ 7,300 \\ \hline 8,760 \\ \hline\hline \end{array}$$

For multiplication (as for addition) the black numbers must be used on the large discs, and before anything else, plain noughts must be placed in the openings. And because in this method of reckoning small discs are also used, noughts must at first be placed on them. Let the numbers 365, as in the case of addition, be placed on the arcs. One of the hands, working from the centre, points to the units on the small discs, and shows that multiplication will be effected with the units as long as the hand is unaltered. Now if the handle be turned round once, the numbers 365 will appear on the larger discs, instead of the noughts which were there previously. But on the smaller discs where the hand points, the number (1), and this proves,—that the numbers 365 have been carried once under the aperture of the large disc. The handle is again turned, and there will be seen on the large disc the numbers 730 and on the smaller one the number (2). But it must in the units' place be multiplied by (4), and so the handle has to be turned four times round, and there will then appear on the large disc the number 1,460, and on the smaller the number (4), and therefore, in this problem, enough has been done with the units. Since 365 had to be multiplied by 24, the operation is repeated twice in the tenfold numbers, and the desired result obtained; this is effected in the following way:—

The hand acting from the centre must be placed on the second disc, which corresponds to tens. Near to the spot where the handle has its resting-point, there is at the circumference of the machine a steel catch pressed down in a notch; this must be lifted up, and so turned round at the circumference of the machine that the hand working from the centre comes to point on the *tens* disc, and as in this case the catch will be pressed into the newly found notch, the handle being turned round twice, the product 8,760 will be found in the openings of the large discs.

For division the red figures must be used, as in the case of subtraction. As an example take the number 8,760, which was obtained by the first multiplication, and divide it by 365. The number 8,760 must be placed on the large discs, in red figures, under the openings. The divisor 365 must be placed on the arcs; the first digit of the divisor (3) must be turned round under the first digit of the dividend, viz., under the number (8); on the small discs noughts must everywhere be placed. The catch must be left in the notch. Now 3 can be taken from 8, the handle is turned once round, and the numbers 5,110 appear, which is the remainder after 3,650 has been taken from 8,760. 3 can again be taken from 5; the handle is again turned round once more, and the remainder 1,460 appears. Since 3 cannot be taken from 1, the catch is lifted, and 3, the first digit of the divisor, brought under the 4 in the dividend. The handle is then turned 4 times, and the remainders, 1,095, 730, 365, and 0, appear in succession, being those due to the successive subtractions of 365 from 1,460. The value of the quotient is seen to be as follows, 3,650 or 365 × 10 is subtracted twice, giving 20 as the first part of the quotient, then 365 is subtracted 4 times, giving 4 as the second part, with no remainder; thus the quotient sought is 24.

40. Tide Calculating Machine.

Sir William Thomson, F.R.S.

The object is to predict the tides for any port for which the tidal constituents have been found by the harmonic analysis from tide gauge observations: not merely to predict the times and heights of high water, but the depth of water at any and every instant, showing it by a continuous curve, for a year, or for any number of years in advance.

This object requires the summation of the simple harmonic functions representing the several tidal constituents to be taken into account, which is performed by the machine in the following manner:—For each tidal constituent to be taken into account the machine has a shaft with an overhanging crank, which carries a pulley pivoted on a parallel axis adjustable to a greater or less distance from the shaft's axis, according to the greater or less range of the particular tidal constituent for the different ports for which the machine is to be used. The several shafts, with their axes all parallel, are geared together so that their periods are to a sufficient degree of approximation proportional to the periods of the tidal constituents. The crank on each shaft can be turned round on the shaft and clamped in any position: thus it is set to the proper position for the epoch of the particular tide which it is to produce. The axes of the several shafts are horizontal, and their vertical planes are at successive distances one from another, each equal to the diameter of one of the pulleys (the diameters of these being equal). The shafts are in two rows, an upper and a lower, and the grooves of the pulleys are all in one plane perpendicular to their axes. Suppose, now, the axes of the pulleys tò be set each at zero distance from the axis of its shaft, and let a fine wire or chain, with one end hanging down and carrying a weight, pass alternately over and under the pulleys in order, and vertically upwards or downwards (according as the number of pulleys is even or odd) from the last pulley to a fixed point. The weight is to be properly guided for vertical motion by a geometrical slide. Turn the machine now, and the wire will remain undisturbed, with all its free parts vertical and the hanging weight unmoved. But now set the axis of any one of the pulleys to a distance $\frac{1}{2}$ T from its shaft's axis, and turn the machine. If the distance of this pulley from the two on each side of it in the other row is a considerable multiple of $\frac{1}{2}$ T, the hanging weight will now (if the machine is turned uniformly) move up and down with a simple harmonic motion of amplitude (or semi-range) equal to T in the period of its shaft. If, next, a second pulley is displaced to a distance T′, a third to a distance T″, and so on, the hanging weight will now perform a complex harmonic motion equal to the sum of the several harmonic motions, *each* in its proper period, which would be produced separately by the displacements T, T′, T″. Thus, if the machine was made on a large scale, with T, T′... equal respectively to the actual semi-ranges of the several constituent tides, and if it is turned round slowly (by clockwork, for example), so that each shaft goes once round in the actual period of the tide which it represents, the hanging weight would rise and fall exactly with the water level as affected by the whole tidal action. This, of course, could be of no use, and is only suggested by way of illustration. The actual machine is made of such magnitude that it can be set to give a motion to the hanging weight equal to the actual motion of the water level reduced to any convenient scale: and provided the whole range does not exceed about 30 centimètres, the geometrical error due to the deviation from perfect parallelism in the successive free parts of the wire is not so great as to be practically objectionable. The proper order for the shafts is the order of magnitude of the constituent tides which they produce, the greatest next the hanging weight, and the least next the fixed end of the wire: this so that the greatest constituent may have only one pulley to move, the second in magnitude only two pulleys, and so on. In the actual machine there are 10 shafts, which, taken in order from the hanging weight, give respectively the following tidal constituents:

1. The mean lunar semi-diurnal.
2. The mean solar semi-diurnal.
3. The larger elliptic semi-diurnal.
4. The luni-solar diurnal declinational.
5. The lunar diurnal declinational.
6. The luni-solar semi-diurnal declinational.
7. The smaller elliptic semi-diurnal.
8. The solar diurnal declinational.
9. The lunar quarter-diurnal, or first shallow-water overtide of mean lunar semi-diurnal.
10. The luni-solar quarter diurnal, shallow-water tide.

The hanging weight consists of an ink bottle with a glass tubular pen which marks the tide level in a continuous curve on a long band of paper moved horizontally across the line of motion of the pen, by a vertical cylinder geared to the revolving shafts of the machine. One of the five sliding points of the geometrical slide is the point of the pen sliding on the paper stretched on the cylinder, and the couple formed by the normal pressure on this point, and on another of the five, which is about 4 centimètres above its level and 1½ centimètres from the paper, balances the couple due to gravity of the ink bottle and the vertical component of the pull of the bearing wire, which is in a line about a millimètre or two farther from the paper than that in which the centre of gravity moves. Thus is ensured, notwithstanding small inequalities of the paper, a pressure of the pen on the paper very approximately constant, and as small as is desired.

Hour marks are made on the curve by a small horizontal movement of the ink bottle's lateral guides, made once an hour; a somewhat greater movement, giving a deeper notch, to mark the noon of every day.

The machine may be turned so rapidly as to run off a year's tides for any port in about four hours.

It is intended that each crank shall carry an adjustable counterpoise, to be adjusted so that when the crank is not vertical the pulls of the approximately vertical portions of wire acting on it through the pulley which it carries shall, as exactly as may be, balance on the axis of the shaft, and that the motion of the shaft shall be resisted by a slight weight hanging on a thread wrapped once round it and attached at its other end to a fixed point. This part of the design, planned to secure against " lost time " or " back-lash " in the gearings of the shafts, and to preserve uniformity of pressures between teeth and teeth, teeth and screws, and ends of axles and " end-plates," was not carried out, but can easily be applied to the machine now exhibited.

The general plan of the screw gearing for the motions of the different shafts is due to Mr. Légé, the maker of the machine. The construction has been superintended throughout by Mr. Roberts, and to him is due the whole arithmetical design of the gearing to give with sufficient approximation the proper periods to the several shafts.

40a. Sir William Thomson's Instrument for Harmonic Analysis of Tidal Observations, and for other uses. It includes a disc-ball and cylinder integrator of Professor James Thomson. For explanations, reference may be made to proceedings of the Royal Society for February 3, 1876.

Sir William Thomson.

41. Pascal's Calculating Machine (1642).

Conservatoire des Arts et Métiers, Paris.

42. Petroff's Arithmetical Apparatus.
M. Petroff, Kalouga.

43. Arithmometer, with measuring apparatus, and the full size skeleton of the square metre and cubic metre, folding up by means of a hinge. *Frère Memoire Piron.*

43a. Counting Machine.
P. N. Dadiane, St. Petersburg.

43b. Calculating Machine.
P. N. Dadiane, St. Petersburg.

45. Model of Gas Meter Counting Machine.
Council of King's College, London.

46. Cavendish's Original Counting Machine.
Council of King's College, London.

III.—MISCELLANEOUS.

48. Apparatus for the Statistical Treatment of large numbers of Seeds, &c., to sort them rapidly into classes differing by regular gradations of magnitude, with the view of testing how far the relative numbers in the several classes accord with the results of the Law of Error or Dispersion.
Francis Galton, F.R.S.

It consists of a square box, having parallel bars fixed across its top at equal distances apart. An equal number of similarly arranged bars are connected by means of rods running along their ends, like the bars of a gridiron, thus forming a framework that is laid on the top of the box. Hence there are two systems of parallel bars in the same plane, one of which is fixed and the other movable. When the frame is pulled forwards as far as it can go, each of its bars presses along its whole length against one of the fixed bars, and when it is pushed gently back the framework bars separate simultaneously and equally from the fixed bars, and any objects that may have been laid between their edges, and are small enough, will drop through. The bars are bevelled along their opposite faces, in order to receive these objects. The framework is moved by a screw turned by a ratchet wheel, which is itself moved by the to-and-fro action of a handle between stops, one of which is adjustable at pleasure. Hence, every time the handle is worked, the space between the bars is widened by a definite space, and all the seeds, &c., whose diameter is greater than the original and less than the final space, will drop through. A tray, divided into compartments, slides beneath the box; it is pushed forward through the space of one compartment before giving a fresh movement to the handle, and thus the seeds become sorted into the different compartments. (This instrument was used to illustrate a lecture before the Royal Institution on Friday evening, February 27, 1874.)

49. Apparatus affording Physical Illustration of the action of the Law of Error or of Dispersion.

Francis Galton, F.R.S.

Shot are caused to run through a narrow opening among pins fixed in the face of an inclined plane, like teeth in a harrow, so that each time a shot passes between any two pins it is compelled to roll against another pin in the row immediately below, to one side or other of which it must pass, and, as the arrangement is strictly symmetrical, there is an equal chance of either event. The effect of subjecting each shot to this succession of alternative courses is, to disperse the stream of shot during its downward course under conditions identical with those supposed by the hypothesis on which the binomial law of error is founded. Consequently, when the shot have reached the bottom of the tray, where long narrow compartments are arranged to receive them, the general outline of the mass of shot there collected is always found to assimilate to the well-known bell-shaped curve, by which the law of error or of dispersion is mathematically expressed. (This arrangement was devised, by the exhibitor, to illustrate a lecture before the Royal Institution on Friday evening, February 27, 1874.) When using the machine, tilt it backwards and all the shot will be returned to the receptacle at the top; then set it in its proper position, and the shot will run to the opening whence they distribute themselves. It is now necessary to press to and fro a button at the top of the frame, which sets a small rake in action, which prevents the shot from getting jammed at the mouth of the opening.

50. Practical Approximation to the value of the circumference in terms of the diameter, by means of a right angled triangle having one acute angle $=27° 35' 49{\cdot}636''$.

Edward Bing, Riga.

For the purpose of effecting this object, as well as for answering kindred questions, use is made of a triangle, specimens of which are here exhibited, and of which one angle is a right angle and another is defined by an equation.

SECTION 2.—GEOMETRY.

West Gallery, Ground Floor, Room G.

I.—INSTRUMENTS USED IN GEOMETRICAL DRAWING.

52. Pantograph, by Breithaupt and Son.
Royal High School of Industry, Cassel. (*W. Narten.*)

This pantograph was made for the geodetic collection of the school, in the year 1866, by Messrs. Breithaupt and Son, Cassel. It is used for enlarging and reducing maps and plans. The peculiarity of its construction is the movement of all the arms between pairs of points, by which means friction is as far as possible avoided. The employment of tubes instead of the usual rectangular bars is also to be recommended, by which means bending, which creates errors in the use of the instrument, is avoided; besides which, the weight of the whole is considerably decreased, thus also lessening friction in the movement of the points.

The peculiar construction of this pantograph was invented and carried out by Messrs. Breithaupt and Son, and the instrument possesses great accuracy and facility of use.

53. Pantograph. *Renaud Tachet, Paris.*

54. Pantograph, with free hanging arms of new construction.
Ott and Coradi Kempten, Baviera.

By means of this instrument figures on a reduced or an enlarged scale can be transferred either to paper, stone, or metal.

These pantographs differ in their construction from other similar instruments by not resting on friction-rollers, but are freely suspended by means of metal wires from cast-iron curved standards; thus only a small portion of the weight of the instrument rests on the table. The advantages of this construction are these: easy and secure management of the instrument; any ordinary table may be used of a size sufficient to afford room for the stands, the original, and copy; the accuracy of the graphic representation is greater at less cost.

The guidance of the instrument is so easy and so accurate that with a little practice every outline can be reproduced. Drawings, likewise, can be transferred to substances measuring a certain height, such as lithographic stones, it being only necessary to place frame and original correspondingly higher. In producing enlarged copies the guiding peg and the drawing pencil must be exchanged, and the releasing cord fastened accordingly. The guidance, in making enlarged copies, is also performed with the handle of the tracing pencil with the same accuracy as when making reduced copies.

54a. Horizontal Pantograph, traversing a surface of 36 inches in length by 20 inches in width. Reduction from $\frac{1}{2}$ to $\frac{1}{12}$.
L. Oertling.

LIBRARY OF THE

54b. Pantograph, large model, with double scale and reverse action, belonging to the Indian service. Four of these large instruments are now in use. *M. Adrian Gavard, Paris.*

54c. Frame, containing the **Drawings** of **Pantographs** and **Pantopolygraphs** made by the exhibitor.
M. Adrian Gavard, Paris.

54d. Pantograph by Adrian Gavard, Paris.
S. J. Hawkins.

Size 56 centimeters.

A method of raising and lowering the tracer A by a rack and pinion movement, for use when the reduction of a drawing has to be made on tracing paper, enables the tracer to pass over any irregularity of surface, and thus prevents injury to the paper.

There is also a method of ascertaining when the tracer A, the pencil or central point B, and the fulcrum C, are in a straight line, for use with maps or drawings of irregular scales, and for which there are not any corresponding divisions on the Pantograph. The points A, *b*, C, D, *e* are removed when the instrument is adjusted, and the two small screws *f*, *f* screwed into the head of the tracer and fulcrum.

The instrument is adjusted for the reduction of Ordnance maps 25·34 inches to the mile to 5 chains to the inch or 16 inches to the mile.

54e. Pantograph made at Madrid by Rostriaga, and which has been used at the mines of Almadin since the end of the last century. *Royal School of Mines, Madrid.*

Compass of Proportion, called also military compass, **invented by Galileo** in 1596.
Royal Institute of " Studii Superiori," Florence.

On one side are engraved the arithmetical lines, the geometrical lines, the stereometrical lines, and the metallic lines ; on the opposite side are the polygrafical lines, the tetragonical lines, and the joined lines for the squaring of figures comprised by right angles and curves together. By means of it 40 important operations can be carried on, and it has in addition a quadrant with a squadron of bombardiers, and transversal lines to take the inclination of the scarp of any wall.

Galileo presented compasses of a similar kind, in the year 1598, to the Prince of Holstein, Sagredo, and Bentivoglio, who was afterwards made Cardinal, to Ottone Brahe, to the Count of Luxemburg, and many other gentlemen, both Italians and foreigners, who had gone to Padua to follow the lectures of so eminent a philosopher. He also presented one made of silver to the Archduke Ferdinand of Austria, and to the Landgrave of Hesse.

55. Large Collection of Mathematical Instruments for **Geometrical** and **Fortification Drawing,** as well as for **Artillery purposes.** The property of His Highness the Prince Pless, Fürstenstein. *The Breslau Committee.*

This ancient collection, dating from the commencement of the last century, is remarkable for the excellent workmanship and good state of preservation of the instruments.

It contains 19 compasses and 11 accessory parts, 28 rules and scales, two of the same with two keys for fortification drawing, eight triangles and set squares, 10 protractors, two pantographs, and 52 other instruments. In all, 134 pieces.

56. Case of Mathematical Instruments.
Renaud Tachet, Paris.

57. Proportional Compasses. *Renaud Tachet, Paris.*

58. T-squares, Set Squares, and Curves.
Renaud Tachet, Paris.

59. Diagonal Scale.
Geneva Association for the Construction of Scientific Instruments.

60. Scales made of **Mica,** for use in geometrical drawing.
Max. Raphael, Breslau.

275. Meter-measures, constructed of mica.
Max. Raphael, Breslau.

These measures have the advantage of being transparent, and may serve for copying geometrical drawings. Owing to their remaining unaffected by the ordinary changes of temperature they may also be used as *standard* measures.

61. Perspective Apparatus invented by James Watt.
Bennet Woodcroft, F.R.S.

62. Set of Mathematical Instruments, with all the modern improvements; as used by professional draughtsmen, &c.; illustrated by diagrams of work performed. *Wm. Ford Stanley.*

62a. Magazine Case of Drawing Instruments.
Henry Porter.

64. Case of Mathematical Instruments, probably Dutch, made at the beginning of the 18th century. *Lewis Evans.*

65. Two Magazine Cases of Drawing Instruments.
Mark Eames.

65a. Large Magazine Case of Instruments.
G. W. Strawson.

65b. Magazine Cases of Instruments (2).
G. W. Strawson.

65c. Morocco Case of Instruments. *G. W. Strawson.*

65d. Napier's Compasses (Electrum). *G. W. Strawson.*

66. Beam Compass, T-squares, Set Squares, and Curves. *Bock and Handrick, Dresden.*

67. Models of Mathematical Instruments. The ortho-compass and the addition compass. *Prof. L. Zmurko, Lemberg.*

The first of these instruments is constructed so that the points of the compass are always parallel to each other, and perpendicular to the surface of the paper. The second is a compass which can be used also as a protractor, as it contains an apparatus which indicates the amount of opening between the arms.

69a. Photographs of Mathematical Instruments.
Otto Fennel, Cassel.

69d. Révoil Tele-iconograph, altered for perspective drawings enlarged to 20 times on a horizontal plane-table.
M. Georges Sarasin, Geneva.

The instrument consists of a telescope, adapted to a Wollaston *camera lucida*, and fixed on a stand arranged so as to make it a mathematical or scientific instrument; while on a separate stand is placed a plane table for drawing. In order to facilitate the exact grouping of the partial perspectives in accordance with a general cylindrical perspective, and capable of being developed, and in order to permit of drawing while the telescope is inclined at great angles, the following additions have been made to the Révoil model:—1st. A tightening ring with an adjusting screw, which fixes the prism to any point on the thread of the screw by which it is fixed to the eye piece. 2d. A web of six threads crossed at right angles in the focus of the object glass for the purpose of setting the partial images in a straight line and in a direction in accordance with the horizontal or vertical. 3d. A spirit level on the telescope stand to ensure the verticality of the axis of rotation. 4th. A socket and rack joint, permitting the height of the prism above the drawing to be determined whatever be the angle of the telescope and, consequently, the scale of the drawing. 5th. A graduated scale with vernier, giving a reading to five minutes on the horizontal limb. 6th. A method of attaching the instrument to its stand, so as to be at the same time firm and easy to work.

69e. Patent Dotting Pen.
E. O. Richter and Co., Chemnitz, Saxony.

The arrangement is as follows :—

A small toothed wheel adapted to the kind of dotted lines to be drawn is attached to a plate, which, rolling on the paper, lifts a lever, which is again dropped by means of a spring. Attached to this arm is a drawing-pen, easily adjustable, by means of a hinge, to the correct position suited to the wheel. The wheel itself is held in position by a small, somewhat elastic plate, which can be displaced a little for fitting the different reserve wheels on which the kind of lines to be drawn depends.

69f. Patent Compasses with stationary centre point.
E. O. Richter and Co., Chemnitz, Saxony.

These compasses differ from others, chiefly by the centre-point being stationary on the paper, so that the tracing-pen, resting on the paper by its own gravity, moves about the centre-point as axis, whilst the movable pen can be displaced, without removing the compasses from the paper. By these advantages speedy and neat tracing will be achieved, even when the smallest circles are to be drawn.

69g. Patent Compasses, with drawing pen and leaden tube.
E. O. Richter and Co., Chemnitz, Saxony.

69h. Patent Diamond Compasses, for lithography.
E. O. Richter and Co., Chemnitz, Saxony.

69i. Patent Diamond Compasses with drawing pen, for lithography. *E. O. Richter and Co., Chemnitz, Saxony.*

69j. Patent Hatching Ruler (for shading by cross-lines in drawing and engraving).
E. O. Richter and Co., Chemnitz, Saxony.

A ruler is attached to a cylinder which, rolling on a plate, draws the former after it. By means of an endless screw, working in a wheel, the cylinder is moved forward. A cogwheel is attached to the endless screw, in which a bar catches, and by the depression of which the mechanism is put in motion. The depression can be regulated by a screw, by which means the various distances of the lines are obtained. One finger is sufficient for working the ruler by simply pressing on the screw, and holding it until the line is drawn.

69k. Six Setter Diamonds, for lithography.

69l. Five Machine Diamonds, for lithography.

69m. Six Scratching Diamonds, for lithography.
E. O. Richter and Co., Chemnitz, Saxony.

69n. Perspectograph. *Lieut.-General M. W. Smith.*

This instrument is employed to determine the perspective position of a point on the surface of a picture corresponding to any point in nature, the actual position of which is ascertained by means of ground plans, elevations, sections, actual measurement, or otherwise, or else assumed in the composition of a picture. A horizontal line is drawn across the picture and a point assumed upon it to represent the point or centre of view, the perspective point (the two ordinates, of which one parallel and the other perpendicular to the horizontal line are determined by the instrument) is then laid down from the point of view by scale and offset. The manipulation of the instrument is very simple and easily acquired; and as the perspective representation of any number of points, constituting lines, planes, solids, &c., can be rapidly transferred to the picture, the most complicated problems of perspective, whether rectangular or oblique, can be performed without lines of geometrical construction, or the transferrence of the subject from a plan previously prepared to the picture. A detailed description of the working of these instruments, as well as of the system upon which their construction depends, will be found in "Engineering," 1876.

69o. Pointfinder. *Lieut.-General M. W. Smith.*

This instrument is used in sketching from nature and is employed to determine a point on the surface of the picture corresponding to any point in nature to which the sights of the instrument may be directed, as follows:—Having drawn a line horizontally across the paper to represent the horizontal line, and assumed a point upon it as the point of view, the instrument is set to zero both on the horizontal, and side vertical graduated arcs; and levelled by means of the small plumb bob, the sights being at the same time upon any point in nature which may be chosen as the point of view. The sights of the instrument are then directed to any point in nature which it may be desirable to introduce into the picture. This may be done by the lateral and vertical movements of the horizontal disc and plate to which the sights are attached; the divisions and subdivisions indicated by the zero mark on the horizontal disc, and index on the side arc, are then read off and transferred to the picture by means of the graduated scale and offset, the zero of the scale being placed to the point of view and the bevelled edge to the horizontal line, the offset is then moved along the edge of the scale till the bevelled edge corresponds with the division or subdivision read off from the circular disc, when a slight dot with the point of a pencil at the division or subdivision on the offset corresponding to the reading on the side vertical arc will indicate the point which is the perspective representation of the point in nature. The scale can be increased, if desired, by multiplying the number of divisions or subdivisions read off on the graduated arcs by 2, 3, 4, or any other common multiplier. The offset also may be dispensed with by placing the edge of the scale first to the horizontal line, for the first reading making a slight mark on the line with a pencil at the number indicated, and then perpendicular to it for the second reading, this may be the most convenient mode of laying down the points when the sketching book is held in the hand. The stand of the instrument folds up, and the apparatus when packed is very light and portable, consisting of camp stool, drawing book, instrument and stand.

443a. Plate Glass Sector, designed for the purpose of plotting angles on plans or charts where it is necessary to see the work under the sector, and the divisions being on the side next the paper no variation in pricking off can take place.

Thos. F. Chappé, M. Inst. C.E.

Boxwood Beam Compasses.

Bock and Handrick, Dresden.

244. Scales, of boxwood, showing the equivalents of English and Foreign measures of length. *Aston & Mander.*

The bevel edged set square slide is used to show the divisions coinciding; and the equivalent values of English and Foreign measures of length may thus be readily obtained.

245. Plotting Scales. Ivory. Two specimens, to show fine and accurate dividing. *Aston & Mander.*

No. 1 shows two chains to the inch, represented by 200 divisions to the inch.

No. 2 shows one chain to the inch, represented by 100 divisions to the inch.

II.—INSTRUMENTS FOR TRACING SPECIAL CURVES.

70. Conograph. An instrument by which the various conic sections may be drawn.

a. Ellipso-Parabolograph.
b. Hyperbolograph.

Dr. Lawrence Zmurko, Lemberg.

This instrument consists of two movements independent of, and perpendicular to, each other; the first of these is set in action by turning a disc, the second by means of a spring. These movements are so contrived that the extent of the second motion shall be such a function of that of the first as to cause a conic section to be described.

71. Cycloidograph. An instrument for tracing cycloids.
Dr. Lawrence Zmurko, Lemberg.

71a. Instrument for tracing with accuracy ellipses and spirals up to 25 centimetres. *M. Adrian Gavard, Paris.*

72. Instrument for drawing **Conic Sections.**
Edward Uhlenhuth, Anclam, Pommerania.

This instrument, which was invented by the exhibitor, shows in the first place the formation of the parabola. By altering the arrangement, the construction of the ellipse and hyperbola easily follows.

73. Elliptic Compass. *Renaud-Tachet, Paris.*

74. Colonel Peaucellier's Compound Compass.
Conservatoire des Arts et Métiers, Paris.

75. Compound Geometric Chuck, producing the kinematic retrogressive parabola, by continuous motion; either on a moving plane by a fixed point, or on a fixed plane by a moving point. *Henry Perigal.*

76. Machine for **Compounding two Simple Harmonic Curves.** Invented and constructed by the exhibitor.
A. E. Donkin.

A strip of paper is wound round the cylinder; the little glass pen moving backwards and forwards on it draws one curve, a similar motion of the cylinder the other. Since both move at once the curves are combined, and the result rendered visible to the eye by the revolution of the cylinder.

A. Eccentric for giving simple harmonic motion to pen.
B. " " " cylinder C.
D. } wheels for determining relative numbers of vibrations of pen and
E. } cylinder.
F. Wheel for transmitting slow motion to pinion G which turns the cylinder.
H. Idle wheel.
I. Change wheels to supply different ratios of vibration of pen and cylinder.

76c. Bow and Scale for Exhibiting Elliptic Functions. *A. G. Greenhill.*

76e. Spherical Rules and Squares for Spherical Drawing. *Dumoulin Froment, Paris.*

76a. Rough Model of the Trace-Computer, designed by the Exhibitor, for the use of the Meteorological Office.
Francis Galton, F.R.S.

Given two ordinates having the same abscissa, the instrument, of which this is a working model, pricks out a third ordinate that shall be some desired function of the other two. The original instrument was contrived for the use of the Meteorological Office, where it is employed to derive the trace for humidity from the traces of the dry and wet bulb thermometers. It consists of a horizontal slab, whose upper surface has been shaped, as hereafter described, in accordance with the numerical tables that have been calculated from the desired function, the height of its surface at each point being the tabular value corresponding to the two entries severally represented by the distance of that point from the front and from one side of the slab. The plate that carries the two traces is placed horizontally on a frame that travels in front of the slab. Two slides move at right angles to this plate, and have microscopes attached to them, that traverse the paper along ordinates having the same abscissa. One of these slides is rigidly connected with a frame on which the slab is able to move from front to back; when this slide is pushed, the frame and the slab together are pushed with it. When the other slide is pushed, it also gives a sidelong movement to the slab on the frame by means of a toothed wheel acting on a rack. Thus the particular point of the slab that corresponds to the values of the two ordinates is brought vertically below a descending rod, and this is caused to drop gently on the surface of the slab by touching a treadle. The vertical space through which the rod descends is consequently the function required. The rod carries a horizontal pricker, with which it makes a dot on a plate held vertically in the same stage that carries the plate on which the two traces are drawn. The slabs can readily be fashioned by instrument-makers, who possess the necessary apparatus, according to any required tables. They are drilled to the requisite depth at various points, and are afterwards smoothed down. In the machine in use at the Meteorological Office, there are many additional appliances not shown in this rough model.

76b. Rule, with joint, which serves to curve an elastic plate into an arc of the circle, of any radius.

Professor Tchebicheff, University of St. Petersburg.

3099. Intersecting Compasses (Arcograph).

Geodetic Institute of the Royal Polytechnic School at Munich, Prof. Dr. von Bauernfeind.

The Arcograph serves to describe upon a given chord a circle the arc of which contains a given angle. The exhibitor, by this invention, has supplied the wants of the practical geometrician in solving, graphically, and without construction Pothenot's problem and all the problems which are described in geometry as "Rückwärtseinschneiden". *See* Bauernfeind's "Elemente der Vermessungskunde," 5th edition, Vol. II., pp. 167–173.

III.—MODELS OF FIGURES IN SPACE.

COLLECTION OF MODELS OF RULED SURFACES, CONSTRUCTED BY M. FABRE DE LAGRANGE, IN 1872, FOR THE SOUTH KENSINGTON MUSEUM.

This collection illustrates the principal types of the class of surfaces which can be traced out in space by the motion of a straight line.

These surfaces, on account of the facility with which they can be constructed and represented, and of the ease with which their intersections can be determined, are of more consequence than any others in the geometry of the Industrial Arts. It is only in small work, which can be put into the lathe, that the class of surfaces of revolution approaches them in respect of general utility. The most important surfaces of all, the plane, the right cylinder, the right cone, and the common screw, belong to both classes.

The representation of the surfaces by means of silk threads is of course only approximate; an approximation of the same character as the representation of a curve by a dotted or chain line, Fig. 1, or by a series of right lines touching the actual curve, Fig. 2.

The models are constructed with especial reference to the possibility of changing their shape, by moving some of the supports of the strings, by altering the lengths or positions of certain parts, or by converting upright forms into oblique. This possibility of *deformation*, as the process is technically called, greatly enhances the value of the models, by allowing them to represent a much greater variety of surfaces than if they were fixed. They are, however, too delicate to be much pulled about, and, unless they are very cautiously handled, the strings are apt to become entangled or break. They should never be used except by a person who understands them, and they should not be shifted without some good reason.

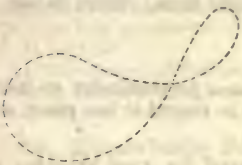


Fig. 1.

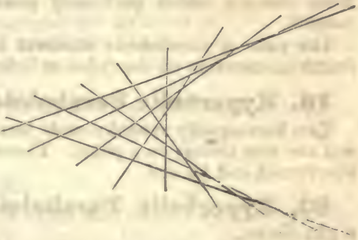


Fig. 2.

Fig. 1 is an example of the first, and Fig. 2 of the second. In both cases, the curve, although not actually drawn, is indicated with sufficient approximation for most practical purposes. Models Nos. 10 and 30 also afford illustrations of the principle exhibited in Fig. 2.

Geometrical drawings of most of the surfaces represented by these models are contained in Bradley's *Practical Geometry* (2 vols., oblong folio, published by Chapman and Hall). Many of them will also be found in the French treatises on practical and descriptive geometry, such as Leroy, Adhémar, Lefebure de Fourcy, De la Gournerie, and in their treatises on *Stereotomy* and *Stone-cutting* (*coupe des pierres*). Many of them are also given in Sonnet's *Dictionnaire des Mathématiques Appliquées*. A catalogue of this collection of models, with an appendix containing an account of the application of analysis to their investigation and classification, was prepared for the South Kensington Museum in 1872, by Mr. C. W. Merrifield, F.R.S. The following descriptions are extracted from this catalogue:—

77. Hyperbolic Paraboloid generated by a single system of right lines.

Two bars, each pierced with holes, equally spaced. One bar is fixed, the other swings round an axis, which, moreover, can be inclined at different angles to the fixed bar.

When the bars are parallel the strings indicate a plane. When they are clined to one another, but still in the same plane, the strings still indicate a plane; but when the bars are not in the same plane, the surface is the hyperbolic paraboloid.

The surface is sometimes called the *twisted plane.* But it must not be supposed that it can be made by bending a plane. On the contrary, when the surface *is* twisted, no two of the strings lie in the same plane, and, therefore, no part of the surface is plane. It can neither be flattened nor made from a plane, without stretching or contraction.

The hyperbolic paraboloid is the natural surface proper for a ploughshare.

78. Hyperbolic Paraboloid.

Two bars, pierced with holes at equal distances, the holes being connected by two different systems of strings. The surface, as well as the arrangement, is very nearly the same as in No. 77, only that there are two paraboloids instead of one. As the movable bar swings round, one paraboloid opens out while the other closes up. If the bars are swung so as to be in the same plane, one system of strings describes a plane by parallel lines, and the other by lines radiating from a point. If one bar is now turned so as to be end for end, we still get a plane, the set of parallel lines now passing through a point, while the set which previously passed through a point has now become parallel.

The pair of paraboloids intersect in three right lines. There is also a fourth intersection on the "line at infinity."

79. Hyperbolic Paraboloid.

Two bars equally spaced; each turns on an arm perpendicular to itself, and one arm swings on a pillar. These arms can be ranged in one plane, and also turned end for end.

80. Hyperbolic Paraboloid generated by two systems of right lines.

A skew quadrilateral with four equal sides, each pierced with the same number of holes, equally spaced. The model exhibits the double generation of the surface. The plane containing two of the sides turns about hinges connecting it with the plane of the other two sides. By closing or opening this hinge the paraboloid opens out or closes. When completely open, it forms a plane divided into *diamonds*. When completely closed it again forms a plane, but the division is no longer uniform. The strings then become tangents to a plane parabola.

81. Hyperbolic Paraboloid.

A skew quadrilateral turning upon four hinges with parallel axes or pins.

The difference between this and the last is not in the kind of surface or mode of generation, but in the manner of *deforming* the surface. In No. 80 the lengths of the strings alter; while in this model they remain unaltered. Moreover, although the surface flattens in two ways, yet in both ways the strings become tangents to a plane parabola instead of parallel.

This model is well adapted for showing the leading sections of the solid All sections parallel to the pins of the hinges are plane parabolas, which degenerate into right lines when taken also parallel to the brass bars. Any other sections, whether perpendicular to the hinges or inclined to them, give hyperbolas, which degenerate into a pair of right lines when the plane of section is a tangent to the surface.

It may be worth while to remark that there is nothing absurd in the tangent plane to a surface cutting that surface, as a student unaccustomed to those subjects might at first think. On the contrary, when a surface is bent one way in one direction, and the other way in the opposite direction, the tangent plane *must* cut it. In this case, the plane passing through any two intersecting strings is a tangent plane, and evidently cuts the surface along each string.

If we imagine two planes parallel to the hinge pins, and each bisecting a pair of opposite bars, we obtain the *asymptotic planes* of the paraboloid, each of which is the assemblage of the asymptotic lines of the hyperbolas parallel to the principal hyperbolic section. Their being asymptotic has reference to these hyperbolas, and not to the parabolic character of the surface.

82. Hyperbolic Paraboloid.

A skew quadrilateral, with its opposite sides equal in length, and pierced with holes at equal distances.

Nearly similar to No. 81, but differently mounted, and with the sides of different lengths, the alternate sides only being equal. It is virtually a slightly different aspect of the same surface as No. 81.

83. Hyperbolic Paraboloid.

A skew quadrilateral, with all its sides equal, and pierced holes at equal distances.

As far as the curved surface is concerned, the same as No. 81. But the hinges are altered in direction, and the model shows plans and elevations of the right line generators of the surface. The rings also show parabolic sections of the surface.

In consequence of the alteration in the direction of the hinges, the spacing of the inclined bars, although equidistant, is at a different pitch from that of the horizontal bars.

84. Hyperbolic Paraboloid.

A skew quadrilateral, with all its sides equal, and pierced with holes at equal distances. It shows the plans and elevations of the right line generators. The rings show the parabolas of the *principal sections.*

No. 83 represents one quarter of what is here shown. The upper corners of Nos. 83 and 84 correspond; but the lower corner of the former corresponds with the middle ring of the latter.

85. Hyperbolic Paraboloid.

A skew quadrilateral, with all its sides unequal. The surface is the same as Nos. 83 and 84, but the proportions and the portion of the surface chosen for representation are different. The quadrilateral base being irregular, the strings alter in length as the surface is deformed by closing the hinges.

86. Hyperbolic Paraboloid.

Skew quadrilateral, pivoting on a single hinge. Intended to show the construction of the parabola connecting two roads which meet obliquely. This construction is used by engineers in laying out roads.

87. Hyperboloid of one Sheet.

Two rings or circles, in parallel planes, are pierced with equally spaced holes. In a certain position the threads give, 1st, a cylinder; and 2ndly, a cone.

The upper ring turns round a pin at its centre. In turning it, the cylinder closes in and the cone opens out, each altering into a hyperboloid of one sheet. We can go on turning the ring until these coincide in one hyperboloid, of which we thus get both systems of generating lines.

If the rings are set on a slope the hyperboloid is elliptic. If the rings are horizontal the hyperboloid is one of revolution.

Sloping one ring, so as not to be parallel with the other, gives rise to some curious ruled surfaces, but these are not in general hyperboloids.

88. Hyperboloid of one Sheet.

Two rings of different radius, in parallel planes, are divided into the same number of equal parts. The smaller and upper ring turns round a pin at its centre. In a particular position of the rings, the threads give two cones. Turning the ring transforms each of the cones into a hyperboloid, and when the two hyperboloids coincide, we get the two systems of right line generators.

The same stand also has a model of a hyperboloid with only one set of strings. By turning the upper ring either way it deforms into a cone; in the one case with its vertex between the rings, and in the other with its vertex a a considerable height above the rings.

Both these can have their upper rings moved along the top bar so as to incline the surfaces. We still get cones and hyperboloids, but it is only when the rings are horizontal, and centre to centre, that we get surfaces of revolution.

89. Hyperboloid of one Sheet, with its asymptotic cone.

90. Hyperboloid of one Sheet, with its asymptotic cone.

The tangent plane to the cone is also drawn. It meets the hyperboloid in two parallel right lines.

One of these right lines is the line of contact of a hyperbolic paraboloid with the hyperboloid, and the tangent plane is one of the director planes of the paraboloid, both systems of generating lines of which are exhibited.

91. Hyperboloid of one Sheet.

A slight variation from No. 90. The paraboloid only shows one system of right line generators, and the tangent plane is made by parallel instead of radiating lines.

92. Hyperboloid of one Sheet, and its tangent paraboloid.

This shows the transformation of a cylinder and its tangent plane into a hyperboloid and its tangent paraboloid.

93. Conoid, with its director plane. The director curve is a plane curve.

By shifting the position of the brasses the conoids deform into different conoids or other allied surfaces.

94. Conoid, with a director cone. The director curve is of double curvature.

By shifting the position of the brasses the conoids deform into different conoids or other allied surfaces.

95. Conoid, showing both sheets of the surface.

By shifting the position of the brasses the conoids deform into different conoids or other allied surfaces.

96. Conoids. Model showing the transformation of a cylinder into a conoid and back again. Also model showing the transformation of a cone into a conoid and back again. It is to be noticed that the head lines of the two conoids, that is to say, the right line in which the two sheets of each conoid meet, are perpendicular to one another.

The transformation is effected by making the upper semicircle turn through two right angles.

97. Conoids.

Intersection of two equal conoids having a common director plane. The horizontal intersection is a plane ellipse.

98. Conoid, in contact with a hyperbolic paraboloid.

99. Conoids. Two equal circles in parallel planes, divided equidistantly, are connected by threads, so as to form four surfaces.

A cylinder. A conoid.
A cone. A second conoid.

The director planes, as well as the head lines, of these conoids are at right angles to one another.

100. Conoids.

Two equal circles in parallel planes are connected by threads so as to form four surfaces.

A cylinder.
A cone.
A conoid.
A second conoid, with its director plane and line at right angles to those of the former.

Same arrangement as No. 99, except that the lower ring is replaced by a plane of section a little higher up. The section gives,—

For the cone, a circle smaller than the upper ring.
For the cylinder, a circle of the same size as the upper ring.
For the conoids, two ellipses turned crosswise.

101. Model exhibiting the simultaneous transformation of a conoid into a cylinder, a cylinder into a conoid, the paraboloid touching the conoid into the tangent plane of a cylinder, and the tangent plane of a cylinder into the tangent paraboloid of a conoid, and reciprocally.

The changes may be arranged as follows :—

From.	Into.
Conoid.	Cylinder.
Tangent paraboloid.	Tangent plane.
Cylinder.	Conoid.
Tangent plane.	Tangent paraboloid.

These changes are all effected simultaneously by one movement, which can be reversed.

102. Model exhibiting the transformation, first, of a conoid into a cylinder; second, of the tangent paraboloid of the conoid into the tangent plane of the cylinder.

103. French Skew Arch (*biais passé*).

The inner drum, of yellow thread, represents this surface. It is a skew surface, with a right line director; and its faces, the planes of the two semicircles, are usually parallel, although the model permits them to be placed obliquely to one another. The horizontal line joining the centres of the two large semicircles is the right line director.

The construction for any one of the generating lines is as follows :—Draw a plane through the right line director at any selected obliquity. It will, of course, give the radii of the outside circles, and the line joining the points at which it cuts the inside semicircles will be a generator of the surface. This line will evidently pass through the director line, because it is in the same plane with it.

In stone or brickwork, the sides of the voussoirs, will be given by the auxiliary plane in question. When the openings are parallel the voussoir joints are therefore plane, and the simplicity thus gained is the chief reason for adopting this form of skew arch. It is usual to take the right line direct or perpendicular to the openings, and symmetrical to them, that is to say, passing through the middle point of the parallelogram of the springing plane.

When the openings are not parallel the voussoir joints shown by the model are deformed into hyberbolic paraboloids. This deformation is, however, very slight, and in practical work would be avoided altogether by adhering to the principle of drawing a plane through the director line.

The opening of the voussoirs is usually determined by dividing the outer semicircle into equal parts.

This form of arch is inconvenient when the obliquity and the length of the barrel are excessive, for the generators are not generating lines of the cylinder containing the opening semicircles, but chords of it, and, therefore, at the middle, falling considerably inside it. The arch, therefore, droops in the middle, and this would be ugly and inconvenient if the proportions were excessive.

104. Staircase Vault for a square wall (*vis St. Gilles carrée*).

105. Staircase Vault. Model for exhibiting some properties of this ruled surface, by showing how it is obtained from the deformation of a cylinder (*douelle de la vis St. Gilles carrée*).

106. Cylinder with Helix and developable Helixoid.

The helix is simply a screw thread. The developable helixoid, shown by the purple threads, is the surface swept out by the right line tangents of the helix. If we consider that each gore can be turned a very little bit about the thread which separates it from the next gore, we see that the surface can be flattened out or developed into a plane, without any crumpling. This happens because every two consecutive generating lines meet one another on the helix. That is why its surface is called developable. Its section by a horizontal plane is the involute of the circle.

The model allows the pitch of the helix to be shortened by lowering the upper plate, and the cylinder can also be inclined. When oblique, however. the curve which replaces the helix is not such a screw thread as can be turned in the lathe.

107. Skew Helixoid.

This surface is described by a right line, which always passes through the axis of a cylinder, and makes a constant angle with that axis. It also passes through a helix or screw thread traced on the cylinder. The model only shows the surface, not the cylinder. The section by a horizontal plane is the spiral of Archimedes. It is the surface of what is known as the screw with a triangular thread.

This is not the commonest form of the skew helixoid; that is best seen on the underside of a screw staircase, or on the driving face of a common screw propeller. In these, two generating lines are at right angles to the axis.

The surface may also be considered as generated by a line which makes a constant angle with a given fixed line, and moves up that line, and at the same time turns round it, at uniform rates.

108. Skew Surface with its tangent paraboloid, capable of transformation into another skew surface while the paraboloid deforms into a plane.

This is (for a certain position of the lower semicircle) a skew surface with a director plane, the plane being vertical. The director curves are: one of them a circle divided equidistantly, the other a semicircle divided so as to keep the strings parallel to the director plane.

109. Intersection of Two Cones having double contact with one another, that is to say, having a pair of tangent planes in common.

The consequence of their having double contact is that their curve of intersection breaks up into two plane ellipses.

The vertices of the cones slide along a rule which turns on a universal joint. See also model No. 114.

110. Common Groin. Intersection of two cylinders having a pair of common tangents. The model may be set square or oblique.

111. Intersection of Two Cylinders, one piercing the other so as to give two separate loops of intersection.

112. Intersection of Two Cylinders, having a common tangent, so as to give a curve having a double point at the point of contact.

113. Intersection of Two Cylinders, neither completely piercing the other, so as to give only one loop of intersection.

114. Intersection of Two Cones, having double contact, along a pair of plane ellipses.

115. Groin. Oblique intersection of two splayed vaults of the same spring.

116. Pair of Intersecting Planes, which, by pulling the brass ball so as to give simultaneous rotation to the two upper rods, deform into paraboloids first, and then into planes described by radiating strings.

117. Intersecting Cylinder and Plane. By pulling the brass ball the head brasses rotate together, and the cylinder deforms into, first, a hyperboloid, and then a cone, while the plane deforms into, first, a paraboloid, and then again into a plane with radiating lines.

118. Pair of Intersecting Cylinders on circular bases. By pulling the brass ball the head brasses rotate together, and the cylinders deform, first, into hyperboloids, and then into cones.

119. Pair of Intersecting Cylinders on irregular bases. By pulling the brass ball the head brasses rotate together, and the cylinders deform, becoming at last cones.

120. Groin.

Model showing the deformation of a common groin, both obliquely, and by splaying the vaults. The model shows not only the intersection, but the plans of the intersection and of the generating lines.

121. Helix or Screw-thread.

Model showing the transformation of the right line generators of a right cylinder into screw threads of various pitch or obliquity.

The pitch of a screw is the distance between two successive turns, measured in a direction parallel to the axis. When this distance is small, the screw is said to have a fine pitch; when great, a coarse or high pitch.

COLLECTION OF MODELS CONTRIBUTED BY THE LONDON MATHEMATICAL SOCIETY.

123. Plücker's Models (14) of certain quartic surfaces, representing the equatorial form of complex surfaces.

London Mathematical Society.

At the meeting of the British Association at Nottingham, in 1866, Prof. Plücker read a paper on "Complexes of the Second Order." On this occasion he showed a series of models constructed by Epkens, of Bonn, of which the above are copies made for Dr. Hirst, and presented to the London Mathematical Society.

The following is Prof. Cayley's description of the models, extracted from Nos. 37 and 38 of the Mathematical Society's Proceedings, vol. iii., pp. 281–285, supplemented by a description of models A, B, C, D, E, F, drawn up by Prof. Henrici.

The Society possesses a series of 14 wooden models of surfaces, constructed under the direction of the late Prof. Plücker, in illustration of the theory developed in his posthumous work "Neue Geometrie des Raumes gegründet "auf die Betrachtung der geraden Linie als Raum-elemente," Leipzig, 1869.

These, all of them, represent, I believe, equatorial surfaces, viz., eight represent cases of the 78 forms of equatorial surfaces, "deren Breiten-Curven "eine feste Axenrichtung besitzen," vol. ii. pp. 352–363; the remaining models, A, B, C, D, E, F, I have not completely identified. I propose to go into the theory only so far as is required for the explanation of the models.

In a "complex," or triply infinite system of lines, there is, in any plane whatever, a singly infinite system of lines enveloping a curve; and if we attend only to the curves the planes of which pass through a given fixed line, the locus of these curves is a "complex surface." Similarly, there is through any point whatever a single infinite series of lines generating a cone; and if we attend only to the cones which have their vertices in the given fixed line, then the envelope of these cones is the same complex surface. In the case considered of a complex of the second degree, the curves and cones are, each of them, of the second order; the fixed line is a double line on the surface, so that (attending to the first mode of generation) the complete section by any plane through the fixed line is made up of this line twice, and of a conic. The surface is thus of the order 4; it is also of the class 4; the surface has, in fact, the nodal line, and also 8 nodes (conical points), and we have thus a reduction = 32 in the class of the surface.

In the particular case where the nodal line is at infinity, the complex surface becomes an equatorial surface; viz. (attending to the first mode of generation), we have here a series of parallel planes each containing a conic, and the locus of these conics is the equatorial surface.

It is convenient to remark that, taking a, b, h, to be homogeneous functions of (x, w) of the order 2; f, g, of the order 1; and c of the order 0 (a constant); then the equation of a complex surface is—

$$\begin{vmatrix} & y & z & 1 \\ y & a & h & g \\ z & h & b & f \\ 1 & g & f & c \end{vmatrix} = 0;$$

and that, writing $w=1$, or considering a, h, b; f, g; c, as functions of x of the orders 2, 1, 0 respectively, we have an equatorial surface.

A particular form of equatorial surface is thus, $bcy^2+caz^2+ab=0$, or taking $c=1$, this is $by^2+az^2+ab=0$, where a, b, are quadric functions of x.

The surface is still, in general, of the fourth order; it may, however, degenerate into a cubic surface, or even into a quadric surface; the last case is, however, excluded from the enumeration. The section by any plane parallel to that of yz is a conic; the section by the plane $y=0$ is made up of the pair of lines $a=0$, and of the conic $z^2+b=0$; that by the plane $z=0$ is made up of the pair of lines $b=0$, and of the conic $y^2+a=0$; the last-mentioned planes may be called the principal planes, and the conics contained in them principal conics. The surface is thus the locus of a variable conic, the plane of which is parallel to that of yz, and which has for its vertices the intersections of its plane with the two principal conics respectively. And we have thus the particular equatorial surfaces considered by Plücker, vol. ii. pp. 346–363 (as already mentioned), under the form

$$\frac{y^2}{Ex^2+2Ux+C}+\frac{z^2}{Fx^2-2Rx+B}+1=0$$

and of which he enumerates 78 kinds, viz.: these are—

1 to 17. Principal conics, each proper.
18 to 29. One of them a line-pair.
30 to 32. Each a line-pair.
33 to 39. Principal conics, each proper, but having a common point.
40 to 43. One of them a line-pair, its centre on the other principal conic.
44 to 61. One principal conic, a parabola.

62 to 73. One principal conic, a pair of parallel lines.
74 to 76. Principal conics, each a parabola.
77 and 78. Principal conics, one of them a parabola, the other a pair of parallel lines.

Model 2. The form of the equation is here,—

$$\frac{y^2}{l^2[(x-\alpha)^2+\beta^2]}-\frac{z^2}{l'^2[(x-\alpha')^2+\beta'^2]}=1$$

viz., the principal conics are one of them a hyperbola, the other imaginary; hence the generating conic has always two, and only two, real vertices, viz., it is always a hyperbola. There are no real lines.

Model 3. The form of the equation is—

$$\frac{y^2}{l^2[(x-\alpha)^2+\beta^2]}+\frac{z^2}{l'^2[(x-\alpha')^2+\beta'^2]}=1;$$

viz., the principal conics are each of them a hyperbola; the generating conic has four real vertices, viz., it is always an ellipse. There are no real lines.

Model 4. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2[(x-\alpha')^2+\beta'^2]}+1=0.$$

The principal conics are one of them an ellipse, the other imaginary; for values of x between γ and δ, the variable conic has two real vertices, or it is a hyperbola; for any other values it is imaginary, so that the surface lies wholly between the planes $x=\gamma$, $x=\delta$. The surface contains the real lines $y=0$, $x=\gamma$, and $y=0$, $x=\delta$.

Model 9. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2(x-\gamma')(x-\delta')}+1=0$$

where, say the values γ, δ, lie between the values γ', δ', the principal conics are each of them an ellipse, the vertices (on the axis or line $y=0$, $z=0$) of the one ellipse lying between those of the other ellipse. The variable conic for values of x between γ and δ has four real vertices, or it is an ellipse; for values beyond these limits, but within the limits γ', δ'—say, from γ to γ' and from δ to δ'—there are two real vertices, or the conic is a hyperbola; and for values beyond the limits γ', δ', the variable conic is imaginary.

There are four real lines ($y=0$, $x=\gamma$), ($y=0$, $x=\delta$), ($z=0$, $x=\gamma'$), ($z=0$, $x=\delta'$). The surface consists of a central pillow-like portion, joined on by two conical points to an upper portion, and by two conical points to an under portion, the whole being included between the planes $x=\gamma'$, $x=\delta'$.

Model 13. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}-\frac{z^2}{l'^2(x-\gamma')(x-\delta')}+1=0;$$

the values γ', δ', lying between γ, δ; the principal conics are one of them a hyperbola, the other an ellipse, the vertices (on the axis or line $y=0$, $z=0$) of the hyperbola lying between those of the ellipse. The variable conic, for values of x between γ', δ', has two real vertices, or it is a hyperbola; for the values, say, from γ' to γ, and δ' to δ, there are four real vertices, or the conic is an ellipse; for values beyond the limits γ, δ, there are two real vertices, and the conic is a hyperbola. There are the four real lines ($y=0$, $x=\gamma$), ($y=0$, $x=\delta$), and ($z=0$, $x=\gamma'$), ($z=0$, $x=\delta'$). The surface consists of eight portions joined to each other by eight conical points, but the form can scarcely be explained by a description.

Model 32. The form of the equation is—

$$\frac{y^2}{l^2(x-\gamma)^2}+\frac{z^2}{l'^2(x-\gamma')^2}=1;$$

viz., the principal conics are each of them a line-pair, the variable conic is always an ellipse.

There are the two real nodal lines ($y=0$, $x=\gamma$) and ($z=0$, $x=\gamma'$), each of these being in the neighbourhood of the axis crunodal, and beyond certain limits acnodal; the surface is a scroll, being, in fact, the well-known surface which is the boundary of a small circular pencil of rays obliquely reflected, and consequently passing through two focal lines.

Model 34. The equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2(x-\gamma')(x-\delta')}+1=0$$

where $x=\delta$ is not intermediate between the values $x=\gamma$ and $x=\gamma'$; say the order is δ, γ, γ'. The surface is thus a *cubic* surface; the principal conics are ellipses, having on the axis a common vertex, at the point $x=\delta$, and the remaining two vertices on the same side of the last-mentioned one. The variable conic for values between δ and γ has four real vertices, or it is an ellipse; for values between γ and γ' two real vertices, or it is a hyperbola; and for values beyond the limits δ, γ', it is imaginary. There are on the surface the two real lines ($y=0$, $x=\gamma$) and ($z=0$, $x=\gamma'$). The surface consists of a finite portion joined on by two conical points to the remaining portion.

Model 40. The form of equation is—

$$\frac{y^2}{l^2(x-\gamma)(x-\delta)}+\frac{z^2}{l'^2(x-\delta)^2}+1=0$$

The surface is thus a *cubic* surface; the principal conics are, one of them an ellipse, the other a pair of imaginary lines intersecting on the ellipse; for values of x between γ and δ, the variable conic has thus two real vertices, and it is a hyperbola; for values beyond these limits it is imaginary, and the whole surface is thus included between the planes $x=\gamma$ and $x=\delta$. There are the two real lines ($y=0$, $x=\gamma$) and ($z=0$, $x=\delta$).

Taking $l^2=l'^2=1$, the surface is—

$$\frac{y^2}{(x-\gamma)(x-\delta)}+\frac{z^2}{(x-\delta)^2}+1=0$$

which is a *particular* case of the parabolic cyclide.

The equatorial surfaces, not included in the preceding 78 cases, Plücker distinguishes (vol. ii. p. 363) as "gedrehte" or "tordirte," say, as twisted equatorial surfaces, the equation of such a surface is—

$$by^2+2hyz+az^2+ab-h^2=0$$

where $b=\mathrm{F}x^2-2\mathrm{R}x+\mathrm{B}$

$a=\mathrm{E}x^2+2\mathrm{U}x+\mathrm{C}$

$h=\mathrm{K}x^2-\mathrm{O}x-\mathrm{G}$ (or in particular $=-\mathrm{O}x-\mathrm{G}$).

Model A. is such a surface, being a twisted form of Model 9.

Model B. belongs to the case $a=0$; viz., the form of the equation is—

$$by^2+2hyz-h^2=0.$$

The variable conic is a hyperbola, the direction of one of the asymptotes being constant (vol. ii. p. 368).

There are, moreover, (p. 372) equatorial surfaces in which the variable conic is always a parabola, and where there are on the surface four real or imaginary singular lines.

In Model C the singular lines are all four real, but two of them coincide with the nodal line at infinity. Consequently, the variable parabola has its axis in a fixed direction. Its vertex moves along a hyperbola which has one asymptote in that fixed direction. The other two singular lines are on opposite sides of this asymptote and parallel to it. When the plane of the variable parabola passes through one of these lines, the parameter vanishes and changes sign. When it passes through the above-mentioned asymptote, the parabola reduces to the line at infinity and the plane becomes asymptotic to the surface. The latter consists of four parts, two on opposite sides of the asymptotic plane between this and one of the singular lines respectively, the other two extending from the singular lines to infinity.

The remaining three models, D, E, F, represent twisted surfaces. Of the four singular lines two are in each case imaginary. The remaining two are real on the first, coincident on the second, and imaginary on the third. Model D consists, therefore, of three, Model E of two, and Model F of one part.

The models are copies from some constructed by Epkens of Bonn. They were presented to the London Mathematical Society by Dr. Hirst, F.R.S. They have been remounted under the direction of Prof. Henrici, by M. Nolet, a student of University College, London.

Some account of complexes and complex surfaces will be found in Dr. Salmon's Geometry of Three Dimensions (3rd edition, pp. 405, 493, 566, 570).

123a. Rough Model of Steiner's Surface.

Prof. Cayley.

Steiner's surface is the quartic surface represented by the equation $\sqrt{x}+\sqrt{y}+\sqrt{z}+\sqrt{w}=0$; where the co-ordinates x, y, z, w, of a point are proportional to arbitrary multiples of the perpendicular distances from four given planes; in the model, x, y, z, w are proportional to the perpendicular distances from the faces of a regular tetrahedron, the co-ordinates being positive for a point inside the tetrahedron.

The surface may be regarded as inscribed in the tetrahedron, touching each face along the circle inscribed in the face. The general form is that of the tetrahedron with its summits rounded off, and with the portions within the inscribed circles scooped away down to the centre of the tetrahedron, in such wise that the surface intersects itself along the lines drawn from the centre to the mid-points of the sides (or, what is the same thing, the lines joining the mid-points of opposite sides). The lines in question produced both ways to infinity are nodal lines of the surface, but as regards the portions outside the tetrahedron, they are acnodal lines, without any real sheet through them; and these portions of the lines are not represented in the model.

The sections by a plane parallel to a face of the tetrahedron are trinodal quartics, which (as the position of the plane is varied) pass successively through the forms:

1. Four acnodes.
2. Trigonoid, with three acnodes.
3. Tricuspidal.
4. Trifoliate, with three crunodes, cis-centric.
5. Do. with triple point at centre.
6. Do. with three crunodes, trans-centric.
7. Twice-repeated circle.

The three nodes are in each case the intersections of the plane by the nodal lines, and the twice-repeated circle is the circle inscribed in the face of the tetrahedron.

123b. Model of a Cubic Surface.

Prof. O. Henrici, F.R.S.

The equation to this surface is $xyz = k^3 (x + y + z - 1)^3$. There are 3 biplanar nodes as shown on the model. The 27 straight lines on the surface are all real, but coincide 9 to each with the 3 black lines drawn on the model.

123c. Sylvester's Amphigenous Surface, a surface of the ninth order. *Prof. O. Henrici, F.R.S.*

This surface is connected with the reality of the roots of equations of the ninth degree.

123d. Model representing the Right Lines on a Surface of the Third Class, having a tangent-plane touching along a conic (the singularity dualistically corresponding to a double-point of the second order).

Elling B. Holst, Stipendiary of the University of Christiania.

The model is composed of twenty-one wires, six of which, painted light red, lie in the same plane and touch the conic in points painted dark red. Through the fifteen points of intersection of these six lines the others, painted white, pass, again intersecting three and three, and are the lines in which the surface cuts itself. All points on these lines have therefore two tangent-planes; where the latter are imaginary the lines are black. The black is in part laid on schematically, especially where the black part contains the point at infinity. The parabolic curve consists of the conic aforesaid and two species of cuspidal curves, viz.:—

1. One curve passing the dark red points and having cusps in those six limiting-points between black and white which are nearest to the conic, the curve therefore having a zig-zag course.
2. Four closed branches having cusps in the other twelve limiting-points.

All these parabolic curves together separate ten distinct ellipsoidally curved parts from the surface everywhere else hyperboloidally curved.

124. Models. A series illustrative of Plücker's Researches in Geometry of Three Dimensions. See explanation No. 123.

Prof. Hennessy, Dublin.

126. Model of the ruled cubic surface called the **Cylindroid.**

Dr. Robert S. Ball, LL.D., F.R.S.

This surface was discussed by Plücker in connexion with the theory of the linear-complex. The kinematical and physical significance of the surface will be found in the "Theory of Screws." The equation of the surface is $z(x^2 + y^2) - 2mxy = 0$.

125. Diagrams (48) showing the Fundamental Principles of the exhibitor's "Organic Geometry of Form."

Prof. Franz Tilser, Prague.

The above work demonstrates the necessity for a reform in geometry, and furnishes the necessary basis for establishing a new system adapted to satisfy the requirements of an exact science. To the above are added 7 "Paragram" Tablets, representing in natural organic connexion a synopsis of the principal elements to be observed in every graphical representation.

127. Models (6) illustrating the relative bases of Descriptive Geometry and the Organic Geometry of Form.

Prof. Franz Tilser, Prague.

128. Drawings. A collection, executed by the Students of the Bohemian Polytechnic Institute, illustrative of the instruction received in the subject of Organic Geometry of Form.
Prof. Franz Tilser, Prague.

129. Two specimens of Wire Stereometrical Models, with letters on cork.
Prof. J. Joseph Oppel, Frankfort-on-Maine.

130. Two specimens of Wire Trigonometrical Models, with letters. *Prof. J. Joseph Oppel, Frankfort-on-Maine.*

131. Two specimens of Wooden Stereometrical Models, with letters.
Prof. J. Joseph Oppel, Frankfort-on-Maine.

The auxiliary lines, diagonals, &c. are distinguished by wires of different colours or thicknesses. They are in many cases movable, so that the perfect figure can be constructed before the eyes of the pupil.

Auxiliary planes are also distinguished by their colour. The angular points are provided with metal pins, to which letters on cork discs can be attached, so as to be turned upright towards the observer.

These models have proved highly serviceable for instruction during the past 20 years.

132. Large Model of an Ellipsoid, of white cardboard, on a turned stand. *Prof. Dr. A. Brill, Munich.*

133. Cardboard Models of Surfaces of the second order, on frames. Made up of circular sections. The sections are attached to each other. *Prof. Dr. A. Brill, Munich.*

This collection of models consists of :—

1. **Ellipsoid** having 20 circular sections.
2. **Ellipsoid** having 30 circular sections.
3. **Hyperboloid** of one sheet.
4. **Hyperboloid** of two sheets.
5. **Elliptic Paraboloid.**
6. **Cone** in two sheets.
7. **Hyperbolic Paraboloid.**

141. Series of Cardboard Models of Surfaces, of the second order, in a cardboard box. The sections are not attached to each other. *Prof. Dr. A. Brill, Munich.*

These models, Nos. 132, 133, 141, are distinguished from those in common use by their mobility, by means of which each one represents not only a single ellipsoid or hyperboloid, but a series of surfaces of one or the other kind. For when the angle of inclination of the circular sections is altered, in a direction easily recognised by pressing or drawing out the model, there will be obtained a simple but infinite system, the individual forms of which can be converted from a flat figure through gradually-changing solid bodies to just such another figure with a different relation of axes, without, however, losing its properties.

The equations representing these systems of surfaces are in rectangular co-ordinates :—

For central surfaces :

$$\frac{x^2}{a^2} + \frac{y^2}{\cos^2\psi}\left(\frac{1}{a} - \frac{1}{k}\right) + \frac{z^2}{k\sin^2\psi} = 1, \text{ or } = 0 \text{ (cone)}.$$

For the elliptic paraboloid :

$$\frac{x^2}{a^2} + \frac{y^2}{a^2\cos^2\psi} - \frac{2z}{k\sin\psi} = 0$$

For the hyperbolic paraboloid :

$$\frac{x^2}{a^2\cos^2\psi} - \frac{y^2}{a^2\sin^2\psi} - \frac{2z}{k} = 0$$

Where 2ψ is the inclination of the circular sections, and a and k are real constants. From the first equation it appears that among the series of ellipsoids there will always be a sphere.

142. Model of a Surface of the third order, made in plaster of Paris, with 27 real right lines.

Prof. Dr. Christian Wiener, Carlsruhe.

The construction of the model is described on a placard fixed to the model.

143. Model of the same surface of the third order, in discs of card-board, with 27 real right lines.

Prof. Dr. Christian Wiener, Carlsruhe.

144. Poinsot's Star Polyhedra. *Dr. M. Doll, Carlsruhe.*

These models show the star dodecahedron with 20 points, the star dodecahedron with 12 points, the icosahedron, and dodecahedron.

148. Curvilinear central surface of the Ellipsoid, in four separate pieces. Proportions of the axes of the ellipsoid, 3 : 4 : 5. *Ludwig Lohde, Berlin.*

149. Dupin's Cyclide, according to the calculation of Professor Kummer, at Berlin. Model 0·094 m. diameter.

(*See* Monatsbericht der Akademie der Wissenschaften zu Berlin, 1863, pp. 328 and 336.) *Ludwig Lohde, Berlin.*

150. Kummer's Cyclide. *Ludwig Lohde, Berlin.*

151. Minimum-surface in a recurring number of tetrahedral surfaces.

(Submitted to the Berlin Academy of Sciences by Professor Kummer, on the 6th April 1865.) *Ludwig Lohde, Berlin.*

152. Maximum of Attraction of the Earth's Surface.

Ludwig Lohde, Berlin.

153. Geometric Body, executed in plaster of Paris, called **" Podoid " ;** a transcendental curved surface, which is determined by the variable parallel co-ordinates μ, ϕ, and κ, whose equation represents the elliptic function

$$\mu = \int_0^{\phi} \frac{d\varphi}{\sqrt{(1-\kappa^2\sin^2\varphi)}} = \mathrm{F}\,(\varphi, \kappa).$$

The construction in plaster of Paris embraces the limits $\kappa=+1$ to $\kappa=-1$ and $\varphi=0$ to $\phi=\pi$.

Prof. Dr. Edward Heis, Münster, Westphalia.

154. The same **Podoid,** executed on a smaller scale, embracing the limits $\kappa=+1$ to $\kappa=-1$, $\varphi=0$ to $\varphi=2\pi$.

Prof. Dr. Edward Heis, Münster, Westphalia.

155. Right double circular Cone, of white wood.

Prof. Borchardt, Berlin.

On the one sheet of the double cone are shown, by sections, the circle, the ellipse, and the hyperbola; on the other, the circle, the parabola, and the corresponding hyperbola. The model takes to pieces at the sections.

156. Elliptic Cone, of white and brown wood.

Prof. Borchardt, Berlin.

On the oblique cone are shown the two circular sections, and the elliptic, hyperbolic, and parabolic sections. At the sections of the ellipse and parabola the model takes to pieces; the other sections are shown by the lines defined by the dark and light wood.

157. Ruled Surface of the fourth degree.

Prof. Borchardt, Berlin.

This model represents a surface of the fourth order determined by the equation—

$$\frac{3x^2}{(z-a)^2} + \frac{3y^2}{(z+a)^2} = 1.$$

The surface has two double right lines, between which lies a finite sheet of the surface as shown on the model, whilst beyond each double right line there extends a second and third infinite sheet of the surface. Every horizontal section of the surface is an ellipse. Of these are shown the circular section corresponding to $z=0$, and the two ellipses corresponding to $z=\pm\frac{a}{2}$. The model can be taken to pieces at each of these sections.

158. Rectangular Parallelopiped, intersected by a skew surface.

Prof. Borchardt, Berlin.

159. Right Circular Cylinder, with spiral surface intersecting it.

Prof. Borchardt, Berlin.

These five models, Nos. 155–159, were executed by the late *Ferd. Engel*, known from the drawings, which he has furnished to *Prof. Schellbach's* "Darstellende Optik."

160. String Model, representing a hyperboloid of one sheet. On it are shown the principal ellipse, the asymptotic cone, and a tangential surface, in threads of different colours.

Dr. Wiecke, Cassel.

This model represents by means of strings (kept tight by springs) of different colours the hyperboloid of one sheet and its principal auxiliary surfaces. The two sides of the surface are shown by the green and red strings respectively; the principal ellipse is given by the points at which the strings pass through the network stretched on the frame; the asymptotic cone is shown by yellow, and a tangent plane by white strings.

161. Model in plaster of Paris, representing the eighth part of the former (No. 160) with a developable normal surface, lines of curvature, and edge of regression. *Dr. Wiecke, Cassel.*

This plaster model represents the eighth part of the surface of an hyperboloid of one sheet; it is constructed on the principal ellipse, and shows the principal axes. It is also attempted to demonstrate on this hyperboloid the lines of curvature of the first and second kind, first investigated by Monge. On this account the hyperboloid is bounded on the side opposite to the principal ellipse by a normal surface of which the directrix is one of the lines of curvature of the first kind. The normals are drawn in this normal surface, and produced to meet in the edge of regression, which with two of the normals will then become the boundaries of the normal surface.

161a. Collection of 45 geometrical solids in cut crystal, for purposes of demonstration. *Madame Wentzel.*

162. Intuitive Method of Projection, by movable planes. Cardboard models (19), practically illustrating problems of space. *Frère Memoire Piron.*

162a. Open Frames containing **Photographs** for teaching by projection. *J. and A. Molteni, Paris.*

162b. Projection Apparatus, polyorama for superposed images. *J. and A. Molteni, Paris.*

IV.—REPRESENTATION OF FIGURES IN SPACE BY MEANS OF DRAWINGS ON A PLANE.

163. Diagrams and Models, illustrative of **Descriptive Geometry,** executed by the Frères de la Doctrine Chrétienne, of Paris. *Prof. Pigot, Dublin.*

164. Drawings, executed in the college by the students, showing the nature of the courses of **Descriptive Geometry** and engineering. *Prof. Pigot, Dublin.*

165. Specimens of a series of **simple folding models** for illustrating the various propositions in **Descriptive Geometry.** *Prof. Osborne Reynolds.*

These are specimens of a series of models designed for illustrating the various propositions in descriptive geometry. They are especially designed for lecturing purposes, for which their simple construction, and the capability which they possess of folding into small compass, well adapts them.

These models contain a complete drawing for each proposition. The horizontal and vertical planes are hinged together, so that they can be folded flat, and the lines, planes, and surfaces are represented by coloured strings, which assume their positions when the planes are at right angles.

1. Illustrating the relation between the projections, traces, directions, and lengths of straight lines.
2. Illustrating the relation between the traces of planes, their inclinations, and intersections.
3. Illustrating the relation between the projections of a line and the traces of a plane; also the normal to a plane.
4. Illustrating the relation between the projections of lines and the angles between them.
5. Illustrating the relation between the traces of a cone and the traces of its tangent plane, and hence the method of drawing a plane having a given inclination.
6. Model, capable of opening out flat, so as to show how the horizontal and vertical planes may be represented on a drawing.

166. Stereoscopic Figures, for demonstration and use in the study of stereometry and spherical trigonometry. Edited by Julius Schlotke. *L. Friederichsen and Co., Hamburg.*

166a. Stereograms of the Lines of Curvature of Surfaces. Drawn by the exhibitor. *Prof. J. Clerk Maxwell.*

Lines of curvature of the cyclide of Dupin (4).
Curves on a sphere (4) :—
    α Two systems of orthogonal circles.
    β Concyclic spherical ellipses. (This represents a spherical harmonic of the second degree.)
    γ Confocal spherical ellipses.
    δ The projections of a spherical ellipse on the three principal planes.
Quadric surfaces (4) :—
    Elliptic paraboloid, hyperbolic paraboloid, ellipsoid, and the surface of centres of ellipsoid.
Fresnel's wave surface (3):—
    The lines are in the direction of the vibrations of the two polarized rays.
Steiner's surface (2).
Twisted cubics (2) :—

$$\text{Curve}\begin{cases} x = a \sin 2\theta \text{ (vertical).} \\ y = b \sin 3\theta \text{ (horizontal).} \\ z = c \cos 5\theta \text{ (perpendicular to paper).} \end{cases}$$

$$\text{Curve}\begin{cases} x = a \sin 2\theta. \\ y = b \sin 3\theta. \\ z = c \sin 7\theta. \end{cases}$$

Icosahedron in octahedron.
22 in all.

166b. Real Image Stereoscope for showing the above. *Prof. Clerk Maxwell.*

The observer places his eyes about two feet from the large lens, and sees the united real images of the figures at or near the surface of the lens.

167. The principal Problems of Descriptive Geometry, represented by stereoscopic figures, by Julius Schlotke.
L. Friederichsen and Co., Hamburg.

168. Stereoscopic representation of a number of the most important crystals, their combinations, &c., by Julius Schlotke.
L. Friederichsen and Co., Hamburg.

☞ The stereoscopic figures of Schlotke are as yet the only ones of their kind in use for illustrating instruction in descriptive geometry and crystallography, in polytechnic and other higher educational institutions, where they are much appreciated.

More particularly the division of crystallography is recommended, as it renders unnecessary the usual expensive models, and, better than those models, demonstrates the combinations and growth of crystals.

A stereoscopic apparatus is placed near the objects.

SECTION 3.—MEASUREMENT.

WEST GALLERY, GROUND FLOOR, ROOMS H. K.

I.—SPECIAL COLLECTIONS.

COLLECTION OF STANDARD MEASURING APPARATUS CONTRIBUTED BY THE STANDARDS DEPARTMENT OF THE BOARD OF TRADE.

A.—*Comparing Apparatus, &c. for Standard Weights and Measures.*

169. Comparing Apparatus for End-Standards of length. Used by Mr. Sheepshanks in the work of the Commission for Restoration of the Imperial Standards, 1844–1850. Constructed by Troughton and Simms.

The standard, and compared end-bars are placed successively on the V supports, with one defining end in contact with the left hand stud and the other defining end with the suspended gravity-piece interposed between it and the screw on the right hand. The micrometer screw is to be gently pressed forward until it just holds up the gravity piece in position, thus ensuring constant pressure for each observation. The readings of the micrometer being taken, the difference of the two readings shows the difference in length of the two end bars to less than 0·0001 inch, which is the value of one division of the micrometer.

To obtain results with scientific precision the temperature of the measuring axis of each bar during the comparison should be known, as well as its rate of expansion. The temperature and length of the bar connecting the stud and gravity piece and of the metal of the apparatus should also be constant.

170. Two Lever Frames, with rollers for supporting standard bars. Such lever frames are used for supporting all the Imperial Standard yards made by the Commission for restoring the Standards. Constructed by Troughton and Simms.

Each bar is supported on the eight rollers of the two lever-frames, which are placed symmetrically under the bar, so that the upward pressure of each of the eight different rollers is necessarily equal, and the length between the defining points of the bar is not altered by its flexure. Equal intervals of supports $= \frac{\text{length of bar}}{\sqrt{n^2-1}}$, where n is the number of supports.

171. Double Micrometer Microscope for comparing the smaller subdivisions of standards of length. Constructed by Troughton and Simms.

It has a movable eye-piece with a double lens, sliding upon a horizontal plate, and two micrometers; and has two object-glasses, each with a double lens, sliding on a horizontal plate parallel to the other plate. The measuring field is about two centimetres in extent, or a little less than 1 inch. Value of one division of each micrometer = 0·00003097 inch, or 0·0007866 millimetres.

172. Apparatus for determining the Expansion of Standard Bars. Constructed by Troughton and Simms.

The trough containing the steel bar with projecting points, distant 1 yard and 1 metre respectively, is filled with melting ice to secure constant length at the temperature of 0° C. The standard bar is placed in the lower trough, with two standard thermometers, and is raised gently against the points. Their impression shows the constant length on the bar at its noted temperature in ordinary air. Next fill the lower trough with melting ice, and take impressions to show the constant length on the bar when at 0° C. Then fill the lower trough with water, and raise to boiling point, or other less high temperature, by the heat from the gas jets underneath, and take impressions to show the constant length on the bar when at 100° C., &c. From the difference of these lengths accurately measured under micrometer microscopes, the rate of expansion of the bar is deduced.

173. Large Callipers for measuring diameter and depth of cylindrical or other measures. Constructed by Troughton and Simms.

These are made on the same principle as the instruments used for measuring shot and the bore of guns at Woolwich. They measure diameters up to 24 inches and within 0·001 inch by the aid of a vernier.

174. Model of Sub-divided Yard with comparing apparatus, for the use of local inspectors of weights and measures. Constructed by Troughton and Simms.

The tested yard measure is placed with its zero defining line immediately under that of the standard. By running the eye-piece along the upper guide bar, each defining line is accurately compared and differences determined to less than 0·01 inch by means of the small supplementary sub-divided inch measure placed also under the eye-piece. This apparatus is described and illustrated in Appendix III., 7th Annual Report of Warden of the Standards, 1873.

175. Spherometer for measuring spherical curves, with true gun-metal plane. Used for measuring the flexure of the middle of the glass disc placed upon the Imperial Standard bushel. Constructed by Troughton and Simms.

When the horizontal plane is made to rest with its three triangular flattened points upon the true plane, the central screw with its micrometer head is accurately adjusted in the same plane, and its reading noted. By substituting for the plane the surface to be tested, its convexity or concavity is determined from the difference of the reading of the micrometer, either − or +. Value of one revolution of the screw = 0·01 inch, and of one division of the micrometer = 0·0001 inch. By interposing a bright beam of light between the point of the screw and the surface tested, and by estimation of 0·1 division, accurate measurements have been made to 0·00001 inch. This instrument is described in Appendix X., 6th Annual Report of Warden of the Standards, 1872.

176. Cathetometer for vertical measurements. Constructed by Troughton and Simms.

For example, for accurately reading a barometer or manometer: place the cathetometer at a convenient distance, and adjust the cross wire of the upper telescope to the level of the mercury in the glass tube, and that of the lower telescope to the level of the mercury in the reservoir. The difference of the two readings on the graduated scale of 42 inches gives the length of the column of mercury to 0·001 inch, by aid of the vernier.

177. Stereometer for ascertaining the density of bodies by determining their volume. Constructed by Troughton and Simms.

This instrument was invented by M. Say (Annales de Chimie, t. xxiii. p. 1, 1797), for determining the specific gravity of gunpowder, and was used with some improvements by Professor W. H. Miller (*See* Phil. Trans. 1856, part iii. p. 800.) for determining the density of the platinum *Kilogramme des Archives*, during his work of restoring the imperial standard pound. The solid body tested is placed in the receiver communicating with the upper end of a vertical glass tube, the lower end of which communicates with that of a second glass tube having its upper end open to the air. The body should nearly fill the receiver, which is screwed up air-tight in its place. Mercury is poured into the second tube, and can be discharged by a stopcock at its lower end. Differences in the relative height of the mercury in the two tubes are noted by means of the cathetometer, as indicating the volume of compressed air under the two conditions, when the body is in the receiver and when it is removed. The volume of the body is deduced from the volume of the mercury contained in the tube between the different heights noted.

178. Balance of new construction oscillating with steel springs. This has been recently constructed by Oertling from a design of Mr. Artingstall.

Its principle is, that, instead of the beam and pans being suspended on knife-edges, thin elastic steel springs are used, and adjustments of knife edges from time to time are thus avoided. It is similar in construction to Steinheil's silk ribbon balance. Its advantages as a balance for weighings, where extreme scientific accuracy is not required, consist in its simplicity and durability; but it appears to be wanting in the sensibility and stability requisite for a balance of precision.

179. Model Kit of Apparatus for Local Inspectors of Weights and Measures. Constructed by Oertling.

This portable collection of all the necessary apparatus for comparing imperial weights and measures has been taken from the *Nécessaire des Vérificateurs*, employed in France for verifying metric weights and measures, with a view to its adoption in this country. It includes a Septimal Balance by means of which a weight of 56 lbs. is compared against 8 lbs., the sum of the standard weights contained in the kit.

180. Experimental Gasholder for determining the internal temperature. Constructed by Messrs. Wright & Co.

By raising and lowering the bulb of the thermometers, the tubes of which are made to slide through the top of the gasholder, the temperature of the gas or air at various heights inside the bell can be read off through the glass side, and the mean temperature determined.

181. King's Pressure Gauge, showing mechanical pressure of gas or air. Constructed by Mr. Sugg.

Standards Department, Board of Trade.

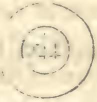
The amount of the mechanical pressure of gas or air contained in a gasholder is shown by this pressure gauge, when it is put in communication with the gasholder by an air-tight tube. The surface of the water in the cistern of the pressure gauge is depressed by the force of the gas or air, and alters the level of a metal cup floating on it. A cord is attached to the float, and passes over a pulley, the spindle of which, aided by friction rollers, carries a pointer moving on a graduated dial, and thus indicates the amount of pressure in hundredths of an inch.

Specimens of Standard Weights and Measures.

182. Copy of Standard Weight, 112 lbs., of Queen Elizabeth.

One of two similar bronze weights deposited in one of the old Treasuries of the Exchequer, and fully described in App. IV. to the 7th Annual Report of the Warden of the Standards.

183. Gilt Steel Yard, line measure, of the same form as the imperial standard yard. Constructed by Troughton and Simms.

Well-holes are cut down to the mid-depth of the bar, where the defining lines are cut upon gold studs, thus  the measure being taken at the middle portion of the central transverse line, intercepted between the two longitudinal lines. These lines, including the two transverse guide lines, one on each side of the defining line, are 0·01 inch apart.

184. Steel Yard End Measure, showing the form of end-standard yard adopted by the Standards Commission. Constructed by Troughton and Simms.

The form of the defining ends is that of a spherical surface, whose centre is the centre of the division-line at the middle of the bar's length. The material of the defining end is a highly polished plug of agate, shrunk into a slightly conical hole at the end of the steel bar.

185. Steel Foot End-Measure. Constructed by Troughton and Simms.

186. Two Steel 6-inch End-Measures, one finished and one unfinished. Constructed by Troughton and Simms.

187. 10-Foot Measuring Rod, of pine wood, bound with brass. Constructed by Troughton and Simms.

188. 3-Foot Measuring Rod, of pine wood, bound with brass. Constructed by Troughton and Simms.

189. 1 lb. Avoirdupois Weight, of gun-metal, electroplated with nickel.

Constructed as an experiment of coating brass or bronze with unoxidisable metal. Oxidation, however, is found to occur at points on the surface of the bronze under the nickel coating.

190. 1 Kilogram Weight, of gun-metal, nickel-plated.

191. Set of Glass Avoirdupois Weights, from 7 lbs. to 1 oz., made experimentally of green bottle glass, not subject to hydroscopic influences. The larger weights adjusted with lead shot.

192. Set of Metric Weights, from 1,000 grammes to 1 gramme. Constructed by Salleron, Paris, of opaque glass, adjusted with mercury to the density of brass weights, and hermetically sealed.

193. Specimen of an Enamelled Iron Weight of 56 lbs., made to resist oxidation, by De Grave, Short, and Co.

194. Specimen of a Patent Brass-cased Iron Weight of 14 lbs.

195. Section of a Patent Brass-cased Iron Weight of 14 lbs., showing mode of construction.

196. Copy of Standard Cubic Foot nickel-plated, with filling apparatus. Constructed by G. Glover & Co.

This is a copy of the standard cubic foot bottle, the primary unit from which the gas-measuring standards were derived. It was verified by weighing its contents of distilled water = 62·321 pounds avoirdupois, according to Sir G. Shuckburgh's determination of the weight of a cubic inch of water. It is used as a direct transferrer of a cubic foot of gas or air, which is driven out from it by raising the cistern and thus introducing water from underneath up to the defining line of a cubic foot. By this arrangement, the nearly undisturbed surface of the water is carried upwards and gradually through the entire height of the bottle, without risk of forming air bubbles.

197. Copy of five cubic feet Gas-measuring Standard, made of anti-corrosive metal, by G. Glover and Co., with scale of capacity graduated in feet and minute fractional parts.

The bell is equipoised when at various depths of its immersion in the water of the cistern by a balance, a portion of which hangs from a cord working in a groove in the circumference of a cycloidal wheel, and attached to the axis of the wheel from which the bell is suspended.

198. Copy of a Standard Test Dry Gas Meter, with testing table. Constructed by G. Glover & Co.

Such test gas meters are authorised to be used for testing stationary meters, where the larger gas measuring standards cannot conveniently be used. The accompanying testing table shows it fitted with thermometers and pressure gauges, and with stand pipes for outlet and inlet communications.

199. Model of a Petroleum Testing Apparatus, for ascertaining the temperature at which its inflammable vapour ignites. Designed by T. W. Keates, Esq., and proposed as a standard for use in accordance with authoritative uniform regulations. Constructed by How & Co.

200. Brass Scale of 41 inches, divided into tenths, and of a metre divided into millimetres ; both scales at 62° Fahr. Constructed by Dollond, and now the property of Mr. Petrie.

This possesses some scientific interest, having been compared several times with Shuckburgh's scale by Capt. Kater. He found in 1830, and again in 1831, that 36 inches of the scale = 35·99893 inches of the imperial standard yard, afterwards destroyed in 1834; and assuming the scale of inches to be perfectly correct, that the metre = 39·37045 inches.

Compared at the Standards Office in February 1876, with the bronze official yard, which has a standard metre at 0° C. marked on the same bar. From the mean of six comparisons, 36 inches of the scale = 35·99961 inches of the new imperial standard yard, and the metre = 0·999684 metre, being 0·316 millimetre less than the *Mètre des Archives* at the normal temperature of 0° C.

223b. Fraudulent Balance, seized from a butcher's shop by an inspector of weights and measures.

Standards Department, Board of Trade.

An illustration of the principle of the balance. One of the suspending hooks of an ordinary equal-armed balance is bent outwards thus lengthening that arm of the beam, and enabling the butcher to make about 14 oz. of meat counterbalance a 1 lb. weight on the other end of the beam.

SET OF OLD STANDARD MEASURES LENT BY THE MAYOR AND CORPORATION OF THE CITY OF WINCHESTER.

201. Very old Steelyard Weight, date unknown. Found at Hyde Abbey, Winchester.

202. Set of Standard Troy Weights, from 256 oz. to 1 oz., of Queen Elizabeth. Dated 1588, being the year in which she granted a charter to the city.

203. Set of Standard Weights (avoirdupois), 56 lbs., 7 lbs., 8 lbs., 2 lbs., 1 lb., of Queen Elizabeth, dated 1588, being the year in which she granted a charter to the city. From the Muniment Room, Winchester.

204. Standard Weights (56 lbs., 28 lbs., 14 lbs., and 7 lbs.). Supposed to be of the date of Edward III. From the Muniment Room, Winchester.

205. Standard Yard Measure. Henry VII. From the Muniment Room, Winchester.

206. Standard Quart and Pint of William III. Dated 1700. From the Muniment Room, Winchester.

207. Standard Gallon, Quart, and Pint of Queen Elizabeth, dated 1601. From the Muniment Room, Winchester.

208. Standard Winchester Bushel, given to the Corporation by Henry VII. in the year 1487.

209. Standard Winchester Gallon, given to the Corporation by Henry VII., in the year 1487.

SET OF MEASURING INSTRUMENTS CONTRIBUTED BY SIR J. WHITWORTH, BART., D.C.L., F.R.S.

217. True Planes. The true plane is the foundation and source of all truth in mechanism.

The patent hexagonal surface plate is constructed so as to be supported and suspended from three points, and remains true in either position. The original true planes first exhibited by Sir Joseph Whitworth at the meeting of the British Association at Glasgow, in 1840, were rectangular, and were ribbed, so as to allow of their being supported on three points ; but when large rectangular surface plates were suspended from the two handles a perceptible alteration took place, and they were no longer as true as when supported on the three points.

212. Whitworth's Workshop Measuring Machine, for making difference gauges from correct cylindrical standards of size.

One division of the micrometer wheel represents $\frac{1}{10000}$ of an inch, one quarter of a division, viz., $\frac{1}{40000}$ of an inch can be distinctly felt and gauged.

No proper size of bearing can be made for an axle to work in without having a difference gauge of such size as experience has proved to be best.

214. External and Internal Standard Cylinder Gauge, 1 inch in diameter.

The standard gauges are usually made from $\frac{1}{10}$th to 2 inches diameter, but they are also made for larger diameters.

They are a necessary adjunct to the workshop measuring machine when making difference gauges.

210. Box of Standard Lengths, of end measure, 1 inch to 12 inches.

Either these standard lengths of end measure or the cylindrical standard gauges are used for adjusting the workshop measuring machine; for large dimensions these are preferable.

213. Box of Cylindrical External and Internal Difference Gauges, differing by $\frac{1}{5000}$th of an inch in diameter.

By means of these a workman can feel his way step by step and so make the bore of any number of barrels or tubes exactly the same diameter. They illustrate the importance of small differences in size ; while one fits, another $\frac{1}{5000}$ of an inch less in diameter appears not to fit at all.

A tight fit is not a proper fit, there must be a certain difference in diameter between an axle and the bearing in which it has to work ; what the difference should be depends on a variety of circumstances which experience alone can determine.

213a. Ten Standard Flat Surface Gauges, from $\frac{1}{10}$th of an inch to $\frac{1}{100}$th of an inch varying $\frac{1}{1000}$th of an inch.

They are standards for the thickness of sheet metal and the diameter of small wire; they serve for the correction of the wire gauge.

Cylindrical standards are not made less than $\frac{1}{10}$th of an inch in diameter.

216. Standard Screw Gauge of Whitworth thread.

This gauge is to show the form of the Whitworth standard thread. The two cylindrical parts give the exact diameter of the top and the bottom of the screw threads in universal use; and the angle of the thread is 55°, and is rounded off $\frac{1}{6}$th of its depth.

211. Millionth Measuring Machine.

The screw of this machine has 20 threads to the inch, the screw wheel 200 teeth, and the micrometer wheel is divided into 250, therefore each division represents the one-millionth of an inch.

The end of the fast headstock and the end of the movable headstock are true planes parallel to each other; the ends of the piece to be measured must also be parallel true planes; the feeling piece is a piece of steel about $\frac{2}{10}$ths thick, its sides being parallel true planes, and it is introduced between the standard to be measured and the true plane at the end of the fast headstock; when the proper adjustment has been made the movement of the micrometer wheel one division, viz., one millionth of an inch, will cause the feeling piece to be suspended—friction overcoming gravity.

The power of measurement and the true plane are the two great elements in practical mechanics.

An idea may be formed of the millionth of an inch, from the fact that if a sheet of foreign letter paper were divided into 4,000 thicknesses, each thickness would represent the millionth of an inch.

Apparatus used by Dr. Joule, F.R.S., for ascertaining the Mechanical Equivalent of Heat.

218. Revolving Electro-magnet, used in 1843 for ascertaining the **Mechanical equivalent of Heat.**

Part of the apparatus used in 1843 for the determination of the mechanical equivalent of heat: viz., a revolving piece, holding a glass tube filled with water, and containing an electro-magnet. This worked between the poles of a powerful magnet; and the heat evolved by the rotating electro-magnet was measured by the rise of temperature of the water. In this manner the quantity of heat lost by the circuit was ascertained when the machine worked as an engine; and, on the other hand, the quantity of heat produced when work was done on the machine was also measured. 833 ft. lbs. was the mechanical equivalent of a degree Fahr. in 1 lb. of water, as determined by these first experiments.

219. Calorimeter, containing a **revolving agitator.** This was employed in the experiments on the heat evolved by the friction of water, made in 1849. The equivalent arrived at was 772 ft. lb.

220. Cast-iron Vessel, containing **Friction Disk,** to revolve under mercury. Used in 1849 to determine the mechanical equivalent of heat by the friction of cast-iron against cast-iron. The equivalent arrived at was 775 ft. lb.

221. Electro-magnet consisting of a broad plate of half-inch iron, having a bundle of copper wires coiled round it. Employed in the first determination of the mechanical equivalent of heat.

222. Apparatus for determining the temperature of water at its maximum density.

Used in the experiments on atomic volume and specific gravity by Playfair and Joule (Memoirs of the Chemical Society, vol. iii., 1846). It consists of two tall vessels, connected together by a stop-cock at the bottom, and a trough at the top. A minute difference of the temperature of the water in one of the vessels from that of the maximum density, determines a flow through the trough to the vessel still nearer the temperature of maximum density. The temperature of water at maximum density was thus shown to be 39·1.

223. Paddle Apparatus, by means of which Dr. Joule determined the dynamical equivalent of heat. Described in Philosophical Transactions for 1850, page 65. *Sir William Thomson.*

II.—MEASUREMENT OF LENGTH.

A. STANDARD SCALES.

223a. Model of an Ancient Egyptian Standard Cubit, dated in the reign of King Horus, 9th Pharaoh of the 18th dynasty (1657 B.C.). *Mrs. Chisholm.*

The ancient standard measure, of which this is a copy, was found in the ruins of Memphis, and is now in the Royal Museum at Turin. It is a Royal cubit of seven palms or 28 digits. The total length of this end standard measure is 523·5 millimetres or 20·6 inches, and agrees very nearly with that of several other ancient Pharaonic cubits still existing, as well as with the length of the Royal cubit as deduced by Sir Isaac Newton from the dimensions of the Great Pyramid, the mean length being 525 millimetres. The original natural cubit, or cubit of a man, of 6 palms is also marked upon this measure, being equal to 463 millimetres or 18·24 inches, and also the ancient Egyptian foot of 16 digits, or ⅔ of the natural cubit, and equal to 12·16 inches, or 1·013 English foot. The great span of 14 digits and the small span of 12 digits are also marked.

227. Standard Scale, in porcelain, showing the relations of modern British and ancient Great Pyramid inches.

Prof. Piazzi Smyth.

This scale was prepared to order by M. Casella, of London. It exhibits side by side 25 modern British inches and the same number of ancient Great Pyramid inches, similarly subdivided.

The 0 divisions of both sets of inches coincide at the left hand exactly, but from thence the gradual growth of the difference of 0·001 of an inch per inch in favour of the Great Pyramid scale may be traced, until at the 25th inch the difference amounts to 0·025 of the British inch. At that point, however, it is to be noted that 25 Great Pyramid inches are just one 10 millionth of the earth's semi-axis of rotation, or the nearest earth commensurable and most scientific unit ever yet proposed as a standard of length.

228. Standard Five-Inch Scale, in smoky agate, for microscope sight. *Prof. Piazzi Smyth.*

The material, which came from Brazil, and was worked up and divided to order by M. Jules Salleron, Paris, was chosen as being a natural product of almost infinite age, and therefore settled condition, harder than steel and utterly unoxidisable. The particular standard length adopted is shown for microscopic sight. It depends not on one pair only, but on 20 available pairs of lines, each five inches apart, drawn with a fine diamond point, and is intended to typify both one fifth of the sacred cubit of Israel and one 50 millionth of the earth's semi-axis of rotation.

229. Standard Five-Inch Scale, in white chalcedony, for microscope sight. *Prof. Piazzi Smyth.*

This material, which came out of some ancient Roman palace, is chosen for the same reasons as that last described. The scale is divided on the same system.

230. Standard Five-Inch Scale, in red porphyry, for microscope sight. *Prof. Piazzi Smyth.*

This material came from an Imperial Roman palace to which it had been taken under the Cæsars from some far more ancient Egyptian temple. It was originally quarried by the Egyptians of 3,500 years ago in the rich porphyry district between Thebes and the Red Sea, and it has been adopted for the same reasons as the preceding examples, and the scale is divided on the same system.

232. Standard of Length, derived from the earth's polar axis, which is unique and common to all terrestrial meridians. *Prof. Hennessy.*

This standard, proposed by Professor Hennessy, is a bronze bar, which, at 15° of temperature centigrade, is equal to the fifty millionth part of the earth's axis.

233. Steel Chain, of fifty links, whose total length is the millionth part of the earth's axis, or very nearly 500·5 English inches. It is nearly equal to the half chain of two perches in Irish plantation measure. *Prof. Hennessy.*

235. Standard Yard Measure, German Silver, with one chamfer divided to inches and 10ths, for temperature 60° Fahr. *Elliott Brothers.*

239. Steel Tape Measure, 66 ft. For testing tapes, divided to feet and inches on one side and links on the other. *Elliott Brothers.*

247. Measure of Length, according to natural principles.
Hans Baumgartner, Basle.

250. Half Metre, maple, with points.
Geneva Association for the Construction of Scientific Instruments.

251. Brass Metre. (Grand Duchy of Baden Model.)
Geneva Association for the Construction of Scientific Instruments.

252. Steel 2-Metre Standard, with points. (German Model.)
Geneva Association for the Construction of Scientific Instruments.

253. Brass Standard Metre. (Swiss Model.)
Geneva Association for the Construction of Scientific Instruments.

The Geneva Association for the Construction of Scientific Instruments possesses in its laboratories a machine for the division of straight lines, to the construction of which it has endeavoured to apply all the improvements of modern science. These efforts have been crowned with success, and the increasing reputation of this machine, which may be considered as the most complete at present existing, has obtained for the Geneva Association orders for metrical standards from several European Governments.

The machine is worked automatically, that is, all the process of dividing is done mechanically. Thus, apart from the inaccuracy consequent on the temperature of the operator, it avoids the errors proceeding from inattention or fatigue on his part. Mechanical action has, moreover, the advantage of being more regular, seeing that the motive power is always equal.

An ingenious contrivance enables the correction of errors due to a change of outward temperature during the process of division, to be effected ; thus, at any temperature a correct graduation corresponding to 0° is obtained. By the same means, a division of any length may be made, although the pitch of the thread of the screw of the machine, and the length of the division required, may be incommensurable.

The pitch of the screw has been thoroughly examined and corrected, so as to guarantee accuracy to the $\frac{1}{100}$ of a millimetre.

This machine for dividing straight lines has been used to effect the normal division of the large machine for dividing circles which stands by its side on the same bed of concrete. This application has been the means of exactly ascertaining the coefficient of dilatation of the machine for dividing straight lines. The maximum of error found in the division of the normal circle was less than a second. It is impossible to expect greater accuracy when it is remembered that the arc of a second on the circumference of the divided circle represents about $\frac{1}{400}$ of the millimetre.

259. Standard Metre, with rack motion to be used as a machine for dividing other metres.
Geneva Association for the Construction of Scientific Instruments.

This instrument may be used both as a comparing apparatus, and as a machine for dividing fractions of the metre, for the use of comptrollers of weights and measures. A small pointer or cutter is traversed, by means of a rack, along the meter, while a very simple lock action enables the millimetric displacements of the indicator to be registered without reading the divisions.

259b. Iridio-platinum Standard Metre, in course of manufacture. *Johnson, Matthey, and Co.*

259c. Section of Metre when finished, showing the form determined upon by the International Commission. *Johnson, Matthey, and Co.*

260. 6-foot Measuring Rod, for uneven ground, for engineering and scientific purposes. Designed by the exhibitor, and made by Messrs. T. Cooke & Sons. *Edward Crossley.*

The apparatus consists of a wooden rod 6 ft. in length, with metal terminations containing spherical cups fitting on to spherical heads upon tripod stands. Three tripod stands are required. Each terminates in a flat ring upon which the base of the short pillar carrying the spherical head is horizontally adjustable, and to which it can be clamped. The rod is supported by two tripod stands, while the third is set forward to receive the rod in its next position. The inclination of the rod is read off to half-a-minute in each position by means of a level and arc attached to the centre of the rod. The true horizontal distance is then obtained by applying a tabulated correction for each inclination of the rod.

This instrument will give an accuracy of 1 in 10,000 on any sort of ground, even with a gradient of one in four.

266. Ivory Pocket Measures. *T. Hawksley.*

Containing the Fahrenheit and centigrade temperature scales; English inches divided to $\frac{1}{50}$ in., and centimetres divided into millimetres; designed for the purpose of introducing into everyday use the decimal system of measurement.

269. Foot-scale-plate. A rectangular brass-plate containing twenty different foot-scales, made in 1769 by Adam Steitz in Amsterdam. It is a copy from the original deposited in the Town Hall of Amsterdam. *Prof. Buys-Ballot, Utrecht.*

269a. Meter Diagram. *A. and F. Stanley, New York.*

289. Meter Scale with double divisions, for 0° and 20° C., by Breithaupt and Son, in Cassel.
Mathematical and Physical Institute, Marburg (Prof. Dr. Melde).

295. 2-Meter Standard Measure in steel.
F. W. Breithaupt and Son, Cassel.

This normal 2-meter standard is an end measure, as well as a line measure, with divisions throughout in centimeters, and on both the end decimeters in millimeters. It was graduated on the longitudinal dividing machine, constructed by George Breithaupt in the year 1850, for the temperature of 0° Celsius, as far as 0·01 mm. precision.

Such normal double meters have been made in large numbers on steel, as well as simple normal meters on brass, for the Imperial Commission of Normal Weights and Measures.

With this longitudinal dividing machine a length of one meter may be graduated *uninterruptedly* even to the smallest subdivisions.

296. Standard Scales in Rock Crystal, viz.:

a. Scale of 10 cm.
b. Scale of 15 cm.
c. Scale of 20 cm.

The scales are cut parallel to the axis of the crystal, and are divided into millimeters; the first and the last millimeters are divided into ten parts. The graduation has been carried out by Mr. Brauer in St. Petersburg.

Hermann Stern, Oberstein, Principality of Birkenfeld.

299. Meter in Steel, line measure divided into millimeters.

L. Steger, Kiel.

301. Apparatus for comparing Standard Measures of Length, by Stollenreuther.

University of Munich (Prof. von Jolly).

302. Meter in the form of a ruler with subdivisions.

M. Meyer, Teacher of Mathematics at the Gymnasium, Halle.

In order that the subdivisions of the meter should be clearly understood by the scholars, one side of the square has no divisions, that side is of the exact length of a meter; the second side is divided into decimeters only, the third into centimeters, and the fourth into millimeters.

303. Schönemann's Measuring Wedge, reading to ·01 mm. *Gewerbe Schule at Halle (Director, Kohlmann).*

304. Schönemann's Measuring Wedge, reading to ·01 mm. *Kleemann, Mechanical Engineer, Halle.*

306. Meter-scale in Brass.

Prof. Baron von Feilitzsch, Greifswald.

This scale was constructed at the workshops of Messrs. F. W. Breithaupt and Son in Cassel (Province Hesse), and is remarkable for its great accuracy.

It is divided, on silver-plated brass, into centimeters, and at both ends into millimeters.

309. Original Meter Scale, iron. One of the forty specimens which were delivered to the members of the Meter-Commission in the year vii. of the French Republic; formerly in the possession of Tralles. *Prof. Dr. Dove, Berlin.*

Original Meter Scale by Tralles (of iron).—One of the 40 standards which were delivered to the Commissioners.

Iron Meter à touts.—This meter, which was presented to Hapler by Tralles, was one of the three which the latter had made at the same time, by Lenoir, with the 15 which were distributed among the members of the Commission.

After the completion of the new measurement of degrees performed by Delambre and Mechain, the real length of the meter was determined by the Commission, consisting of, Swinden, Tralles, Laplace, Legendre, Cizcar, Mechain, and Delambre, in their report of the 6th Florèal year 7, to be 443·295936, and the distance of the Pole, by assuming an oblateness of $\frac{1}{334}$, from the equator having been calculated to be 5130 ys toises, it was legally accepted as "*mêtre orai et definitif*" at 443·296.

"Cette unité nommée mêtre qui est le dixmillionème partie du quart du méridian revient selon les anciennes mesures à 3 pieds 11·296 lignes, en employant la toise du Peron à 13 degrés du thermomètre à mercure divisé en 80 parties."

312. Standard Meter on brass in mahogany case. *Ed. Sprenger, Berlin.*

313. Standard Meter on Steel. *Ed. Sprenger, Berlin.*

314. Standard Meter on Wood. *Ed. Sprenger, Berlin.*

315. Standard Tape Measure, 20 meters. *Ed. Sprenger, Berlin.*

315a. Standard Stirling Ell, believed to be a copy of the standard Scottish ell adjusted at Edinburgh, 26th of February 1755. *The Burgh of Stirling.*

315b. Standard Meter. *Bock and Handrick, Dresden.*

Two Standard Meters (boxwood). *Bock and Handrick, Dresden.*

2-Meter Standard Measure. *Bock and Handrick, Dresden.*

B. TELEMETERS.

226. Telemeter. For measuring the distance of inaccessible objects. *Patrick Adie.*

This instrument, the first of its name, was patented by Mr. Adie in 1863. It consists of two powerful telescopes at the ends of a fixed base; the united rays, by total reflection, give simultaneous observation in the eye-pieces.

234. Telemeter, for determining distant inaccessible points by one observation. Manufactured by Adie & Son, Pall Mall. *Prof. Pigot.*

242. Nolan's Range Finder.

1. Two-angle measures. Right and left.
2. Two Y supports.
3. Two tripods.
4. Two tripod buckets.
5. Two leather boxes with straps to contain items 1 and 2.
6. A 50 yards measuring tape.
7. A metal calculating roller.
8. Two magnifying glasses.
9. A leather case with strap to contain items 6, 7, 8.
10. A leather numnah which fits under the saddle of item 1, and on which the two boxes, item 5, are strapped.

War Office.

243. Two Instruments for Measuring Distances. Constructed by Dr. Meyerstein.

Prof. W. Klinkerfues, Göttingen.

262. Telemeter with prism by Col. Goulier for the rapid measurement of distance. *M. Tavernier Gravet, Paris.*

263. Pocket Telemeter. By M. Gautier.

M. Tavernier Gravet, Paris.

264. Telemeters. *Fortin Hermann Bros., Paris.*

285. Collection of War Telemeters. These instruments, which are based on the speed of transmission of sound, are intended for measuring distances in the field.

Le Boulengé, Liége.

307. Instrument for Measuring Distances, according to the systems of Kleinschmidt and Breithaupt.

Royal Museum, Cassel (Dr. Pinder, Director).

The instrument for measuring distances was constructed entirely of brass by J. C. Breithaupt during the second half of the 18th century. It consists of a rail of 0·978 m. in length, serving as measuring-base, on both ends of which is attached a movable telescope for sighting the object the distance of which is to be determined. From the known length of the base, and the indicated angles which the adjusted telescopes form with the base line, the distance sought is ascertained by trigonometrical calculation.

C. GAUGES AND CALLIPERS.

11. Set of Gauging Instruments. *Dring and Fage.*

Head rod. For ascertaining the head diameter of a cask, and working out the contents.

Bung rod and slide. For finding the bung diameter and diagonal of a cask. The rod is divided into inches and tenths, with a line of imperial area and diagonal line; this last gives the approximate content without calculation, and is computed on the assumption that most casks are similar to one another in form, and therefore vary as the cubes of their like dimensions.

Long callipers used for finding the internal length of a cask from head to head.

Cross calliper. Used for finding the external diameter of a cask.

Stave gauge. For finding the thickness of the stave in a cask.

236. Sliding Calliper Gauge, with tangent screw and vernier for reading $\frac{1}{1000}$th of an inch inside and outside measurement. *Elliott Brothers.*

237. Decimal Gauge, German silver, with screw and ratchet motion for measuring to $\frac{1}{1000}$th of an inch. *Elliott Brothers.*

246. Aerial Spider Line Micrometer of great delicacy, measuring an object to the 100,000th of an inch.

Dr. Royston-Pigott, F.R.S.

The image of sets of spider lines of a recording micrometer placed beneath the stage, is formed by a half inch objective, five inches from the spider lines. This image is in fact a miniature diminished exactly seven times. The micrometer reads to the 1–20,000th of an inch, $\frac{1}{20000}''$; consequently the image is measured seven times more minutely. This would be the 1–140,000th, or $\frac{1}{140000}$th of an inch (English). On the whole, therefore, the instrument may be said to measure to the 1–100,000th, *i.e.*, $\frac{1}{100000}$th of an inch.

These aerial spider lines are made to move about the object to be measured at the will of the observer, and come into the focus of the microscope by regulating the plane of the aerial spider lines.

246a. Wollaston's Single Lens Micrometer.

Wollaston Collection, Cavendish Laboratory, Cambridge.

(Phil. Trans., 1813, p. 119.)

256. Callipers, for clock and watch making.

Geneva Association for the Construction of Scientific Instruments.

Much used in clock and watch making for measuring thicknesses. This instrument gauges to $\frac{1}{60}$th of a line, or $\frac{4}{100}$th of a millimetre.

The divisions traced on the steel arc are not equal, but are calculated to measure equal increments of the interval between the two nibs. They increase therefore with the chords.

257. Curious Steel Callipers for very accurate measurement, by Paull of Geneva, 1777. *Royal Society.*

267. Apparatus for **measuring** the exterior **diameter** of the **Gun Barrel** and the interior diameter of the rings to be shrunk on the same; constructed by G. Brauer.

Arsenal of St. Petersburg.

The apparatus consists of a bar, with two adjustable arms, which is suspended across the cannon; one arm being brought into contact on one side with the surface of the cannon, the other arm with its contact lever is brought into contact with the surface of the cannon on the other side, in such a manner that this contact lever at its upward and downward motion, by means of the vertical screw at the greatest diameter, indicates zero. In order to exactly determine the diameter, the divided movable scale is adjusted, after

LIBRARY OF THE

taking off the apparatus from the barrel of the cannon, between the two arms, so that the contact lever again indicates zero. The same scale serves also for measuring the interior diameter of the rings. The apparatus has been constructed and made by G. Brauer at St. Petersburg.

267a. Photograph of an Apparatus for **measuring** the eccentricity of the chamber and the curve of the **bore** of **cannons.**

G. Brauer, St. Petersburg.

The apparatus consists of two parts :—

1. A body, which is pressed into the mouth of the cannon by means of an endless screw. In this screw a telescope is fixed which can be turned about its own axis, and is provided with a filar micrometer and a position circle.

2. A piece, which can be slided along the barrel, being turnable about the axis of the bore, and in whose centre is a glass plate with engraved cross. This cross is viewed through the telescope before mentioned, and the determination of the position of the cross on the filar micrometer indicates the elements for determining the curve of the bore and the eccentricity of the chamber.

The apparatus was constructed by the exhibitor for the Russian Marine Artillery Department.

267b. Instrument for **Measuring** the **Bore of Cannons** (Etoile Mobile). *G. Brauer, St. Petersburg.*

This instrument consists of a ring, in which two parallel rods slide longitudinally side by side, and one of which carries the scale, the other its vernier. The sliding rods are pressed asunder by means of springs, so that their exterior steel ends touch the side of the bore to be measured. As this contact must not take place during adjustment, the sliding rods are brought together by a bolt. A screw perpendicularly under the sliding rods is intended for adjusting them according to the greatest diameter, which has to be done afresh at each measurement. If the chamber of a breech-loading gun is to be measured with the apparatus a set of two rings has to be added, of which the one in front carries a telescope for viewing the scale. The two exterior rings are joined to each other by four bars, and these bars have a movement in the centre ring, which during the operation of measuring is pressed into the back part of the cannon bore by means of four screws, and the whole apparatus is then moved as required.

267c. Apparatus constructed for **measuring** the exterior **diameter** of small **cylinders** with an accuracy of 0·001 inch.

G. Brauer, St. Petersburg.

This apparatus, which was employed in the experiments on the elasticity of gun-metals, steel, cast-iron, &c., in Russia, is provided with an immovable pillar and a contact-lever, which can be adjusted by means of a screw-movement. The cylinder to be measured is placed between the two, and the screw turned until the lever points to zero, and then the reading is effected by the vernier of the longitudinal scale.

267a. Apparatus for Measuring the Breeches of Large Guns. *M. Gadolin, St. Petersburg.*

267d. Apparatus for **Measuring** the **Length** of the **Impressions** made by the **Rodman Scale.**

Technological Institute at St. Petersburg.

The copper plate, on which is the impression to be measured, is placed on the slide of the apparatus, and then one end of the impression after the other is brought under the cross thread of the microscope by means of the screw of the slide, when the reading can be made on the head of the screw. By means of a micrometer eyepiece also smaller dimensions can be measured.

The apparatus belongs to the Technological Institute at St. Petersburg.

267e. Micrometer for Guns and Tubular Objects.

Samuel B. Allport.

This is a tube, provided with three spring arms, radially disposed round its end, between which a cone is inserted. The cone is connected with a screw at the other end of the tube, whereby it is projected or withdrawn, and so contracts or expands the spring arms.

The angle of the cone bears such a relation to the pitch of the screw that the expansion or contraction of the arms when inserted in a tube will indicate the variations in its bore in thousandths of an inch by suitable divisions on the head of the screw.

267e. Apparatus for measuring the eccentricity of the pivots of a polar or transit axis, with an approximation of ·00001 inch.

A. Hilger.

271. Calliper, with **Dial,** of the English inch measure, divided into eighths. *M. Isvard fils.*

272. Calliper, with **Dial** of two centimetres, divided into tenths of a millimetre. *M. Isvard fils.*

283. Cylindrical Gauges differing in diameter by one ten thousandth of an inch. Other gauges and specimens of surfaces.

Royal School of Mines.

284. Universal Calliper, with slide and reverse action.

Geneva Association for the Construction of Scientific Instruments.

Instrument of measurement, for ascertaining equally the thickness, the inner diameter, and length of tubes.

286. Apparatus for measuring accurately the **Diameter** of **Wires,** for testing whether pivots and other turned objects are perfectly circular in form, and for the determination of the error when they are not truly circular.

Landsberg and Wolpers, Hanover.

287. Apparatus for measuring the Thickness of thin metal plates, sheets of paper, &c.

Landsberg and Wolpers, Hanover.

288. Calliper-Compasses for larger measurements.

Landsberg and Wolpers, Hanover.

288a. Photographs, showing two kinds of machines for measuring with great precision the alterations in shape produced in metals by tension and compression. *Dumoulin Froment, Paris.*

291. Calliper Apparatus, for accurately determining diameters and lengths up to 150 mm.
A. Meissner (H. Müller and F. Reinecke), Berlin.

$\frac{1}{25}$ millimeter can be obtained by direct reading by means of a microscope, and the $\frac{1}{250}$ part of a millimeter by estimation.

293. Collection of Timber Callipers for the use of foresters. *C. Staudinger and Co. (F. W. von Gehren), Giessen.*

A collection of tree-callipers ("Baumkluppen"), mostly in use for the purpose of comparison with those of Staudinger's construction, by many authorities recognised as the best. A list of the names is added to the collection.

298. Calliper Compasses, with plane contact lever.
Physical Institute of the University of Kiel (Prof. Dr. G. Karsten).

This apparatus, which is in the possession of the Physical Science Institute of the University of Kiel, was constructed in 1832 by Repsold, and made use of by Schumacher for comparing the platinum kilogramme of the archives with the Danish.

(*See* Schum. Astronom. Jahrbuch, 1836, p. 243.)

A description by G. Karsten of the instrument will be found in "Vom Maasse und vom Messen," vol. I. of the "Encyclopædie der Physik," p. 506 and following.

308. Apparatus for **measuring** the **Thickness** of **Thin Plates.** *R. Fuess, Berlin.*

308a. Improved Patent Measuring Gauge, with patent releasing arm. *Wm. Henry Laidler.*

This gauge is constructed to enter a hole drilled in a plate; the arm will clear any rough edge or burr, and when the measurement is taken the arm can be released, and the instrument withdrawn, without altering or interfering with the indication. Each division on the vernier shows $\frac{1}{1000}$ part of an inch.

308b. Improved Ivory Calliper Gauge, with Engineer's Slide combined. *Wm. Henry Laidler.*

D. CATHETOMETERS.

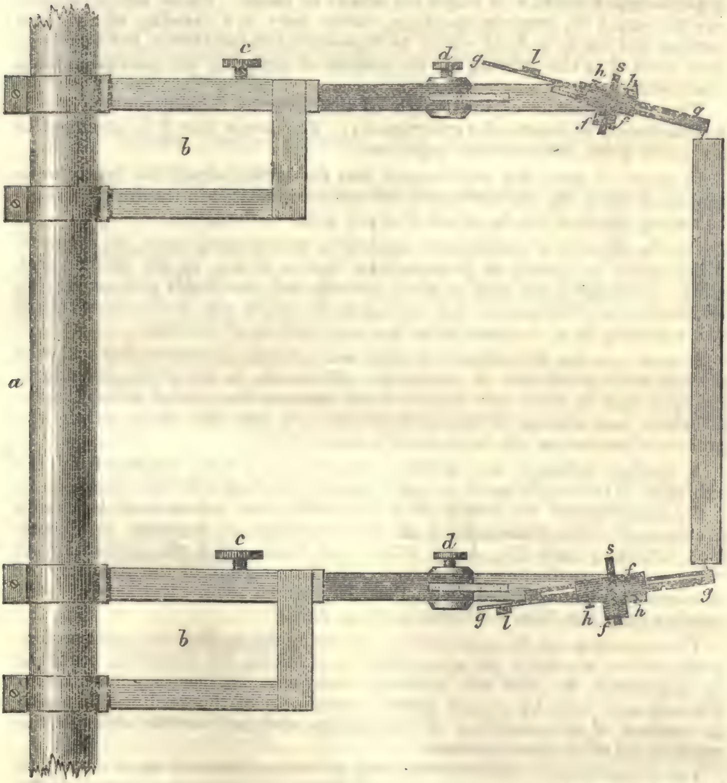
241. Differential Cathetometer, an apparatus designed for measuring variations in the length of solid bodies, particularly of rods and wires. *Dr. Heinrich Streintz, University of Gratz.*

The principle on which this apparatus is based is, reading by reflection from two mirrors. Two levers, having small mirrors *ss* attached to them perpendicular to their axis, are turned by the flat ends of the bar to be measured as indicated in the drawing. If a telescope and a scale are placed, at some distance, in such a position that the image of the scale reflected by the mirror is visible through the telescope, each variation in the position of the point at the end of the lever will be magnified to a degree indicated by the quotient, the numerator of which represents the double distance of the mirror from the scale, and the denominator that of the point from the axis of rotation.

As the latter distance can be diminished to one centimeter in the apparatus, and as, moreover, the telescope with the scale can be placed at any distance within which distinct images will be seen, say five metres, a shifting of the reflected image by one millimeter will be equal to displacement of the end-surface of the bar to be measured by 0·001 millimeter. As, however, the tenths of the millimeter even can be pretty accurately determined, the reading will be correct as far as the 10,000th part.

There is no doubt that the correctness of the reading with this apparatus can be carried still further, if mirrors of superior quality and powerful telescopes are employed.

In measuring the variations in the length of a wire a flat surface must be given to that part to which the wire is to be suspended, as well as to the part on which the weights are placed, and to which the levers are to be applied.



The arrangement of the apparatus is as follows :—

To a solid brass pedestal, which rests on three adjusting screws, a strong glass tube *a* 1¼ meter long is cemented, to which two brass bars *bb* are clamped. Each of these brass bars consists of two parts, of which one moves or slides in the other in such a manner that it can be either lengthened or shortened. The set screw *c* serves for fixing the chosen length. By means of the joint *d* a horizontal rotatory or veering movement of the fore-part of the bar can be effected. Close to its free end there is on each side a steel point—the two forming together an axis—which is held by a bow *ff* carrying two cups, in such a manner that the bow can be easily but surely turned round this axis.

The lever *gg* which must be firmly connected with the bow, has longitudinally a slit, or slide, with two sliding pegs placed in a level position with the axis and fastened to the bow, along which the lever can be moved, so that at whatever distance from the axis the extreme end of the lever may be fixed it must always turn with the bow around the axis.

In order not to be obliged to take the measurement of the length of the lever afresh at each experiment, it is provided at its upper surface with conical-shaped cavities in which the screws *hh* catch. These conical-shaped cavities would be, properly speaking, visible only in a drawing of a vertical section, but not in a front view, as represented in the sketch, but they have been marked in the drawing for the purpose of rendering the description more intelligible.

The measurement of the length of the lever at the different cavities is accomplished by means of a spherometer. The lower bar *b* is arranged in a manner quite similar to the upper bar.

In order to meet the requirement that the levers should but lightly press against or touch the end surfaces in the manner indicated in the drawing, small balancing blocks *ll* can be attached at any point to the levers.

For the purpose of reading, two telescopes with vertical scales are required, which must be placed in juxtaposition, that is to say, by the side of each other. Presuming the staff to move upwards and downwards without varying its length, the difference in the reading in the upper and in the lower mirror will naturally be of the same value in every position of the staff.

A glass tube has been chosen to serve as a column *a*, because glass possesses a very small coefficient of expansion. Moreover, in using the instrument, the tube must be filled with water and two thermometers placed in it, by means of which any change in the temperature that may take place during the process of measuring can be accurately determined.

A similar, although less perfect, apparatus has been employed by the exhibitor in two experiments already, namely, "as regards the variations in "the elasticity and the length of a wire under the influence of a galvanic "current." *See* Transactions of the Academy of Sciences at Vienna, Vol. LXVII., Part II., April 1873; and "respecting the moderation of "the torsion oscillations of wires." *See* Transaction of the Academy of Sciences at Vienna, Vol. LXIX., Part II., March 1874. Extracts of both treatises have also been published in Pogg. Ann.

The apparatus can be employed in measuring the coefficients of expansion, coefficients of elasticity, the after effects of elasticity, the expansion produced by magnetism, &c., and will secure in every case an accuracy not hitherto attained, not only by reason of the correctness of the readings, but also on account of the correction of temperature rendered possible through the employment of the glass column.

The measurement is likewise very easy of accomplishment, since a manipulation such as is the case with ordinary cathetometers is not required, as the variations taking place in the wire can be perceived through the telescope directly magnified and projected on the scale.

In most cases it will only be necessary in making such experiments to know exactly the absolute length of the body to be measured in equal per cents, as well as the elongation, for measuring which a good scale, or a very simple cathetometer, is all that will be required.

241a. Original Cathetometer by Dulong.
Polytechnic School, Paris.

241b. Cathetometer, with two Levelling Micrometer Telescopes.
Physical Science Cabinet of the Imperial Academy of Sciences, St. Petersburg.

241c. Drawing of a small Cathetometer, used by Prof. Mendeleeff in his investigations on the tension of gases.
Prof. Mendeleeff.

In order to eliminate a source of many errors the eyepiece is fixed in the telescope, and the whole cathetometer has to be put at the required distance from the object to be observed.

The telescope is provided with a micrometer screw.

258. Great Cathetometer, for reading differential levels more than a metre apart.
Geneva Association for the Construction of Scientific Instruments.

This instrument is composed of a tripod supporting a central rod, which bears on its upper part the brass column, or prismatic piece, along which the telescope moves in a right line. The dimensions of the column are great, so as to avoid all flexure. The division on the silver plate is in millimeters, and the vernier of the slide gives readings to the 50th of a millimeter. This instrument has two levels; the one placed between the rings that support the telescope, the other placed perpendicularly to the first upon the table situated at the base of the column.

The universities of Berlin, Rome, Dorpat, Neuchatel, &c. have instruments of this pattern.

273. Cathetometer, by Casella. The telescope moves on a girder-shaped brass bar, to which the scale is attached, and is furnished with a micrometer eyepiece, by means of which readings can be taken without moving the telescope. The instrument is supported by a massive iron frame-work.
Prof. A. W. Rücker, Leeds.

292. Cathetometer. *C. Bamberg, Berlin.*

The principal division of the instrument is executed on silver to centimeters. The division into single millimeters has been made on a scale connected with the principal slide, whose divided surface is on a level with that of the centimeter graduation. The millimeter-scale moves with the principal slide, which carries the means for reading and adjustment (microscope and telescope). The reading of the meter-division is effected (as far as 0·001 mm.) by means of the eyepiece-micrometer of the microscope. The micrometrical displacement of the principal slide, which is balanced in all positions round the longitudinal axis of the scale column, takes place by a peculiar contrivance, which avoids all one-sided pressure. The slide with the clamp is balanced by a counter-weight suspended from the ceiling or a trestle, so that its ascending and descending motion is effected with great facility.

294. Photograph of a Cathetometer, constructed by Staudinger and Co.

C. Staudinger and Co. (F. W. von Gehren), Giessen.

The peculiarities of the construction may be learned from the photographs. The instrument has an available graduated length of one meter; the column with the counter-weight turns completely around the long vertical axis, and is provided with adjustments, reversing telescope, and water-level.

305. Cathetometer.

Prof. Baron von Feilitzsch, Greifswald.

The cathetometer consists of a central axis, and a prism turning round the same. For placing the central axis in a vertical position a cylindrical water-level, indicating to 10 seconds, is employed. A scale on silver one meter in length, and divided throughout into millimeters, is inlaid into the prism. Sliding along this is a telescope, likewise fitted with a cylindrical water-level, the supporter of which is provided with a vernier indicating $\frac{1}{20}$ mm.

There is also a water-level, for regulating the direction of the prism.

310. Cathetometer, so arranged as to be used for horizontal measurement. *Prof. Dr. Dove, Berlin.*

311. Cathetometer, by Breithaupt and Son, Cassel, with riding level. *Polytechnic School, Cassel (Dr. E. Gerland).*

The following improvements, contributing partly to more minute readings with the apparatus, partly affording means of correction of the several parts, have been added to the well-known constructions.

The firmly placed central axis, around which the long frame and prism turns, can be placed vertically by a special cylindrical water-level, indicating to 10 seconds, and which is fastened to the frame independently of other parts, in order that the vertical position of the axis required in very fine measurements may be readily ensured; the more so, as all other observations are based on the correct adjustment of this water-level. The vertical position of the axis is effected in the same manner as with an ordinary levelling instrument, and any deviations of the water-level are corrected half on the adjusting screw of the same, and half by the regulating screws of the tripod.

The prism, the inlaid silver scale of which, 1 meter in length, is throughout divided into millimeters, and fitted with a vernier for $\frac{1}{20}$ mm., can be placed in a horizontal position and parallel to the face of the scale. By means of adjusting screws, and a reversible riding level, the telescope can be placed in the required position.

If this is done, the bubble of the telescope water-level will remain unchangeably in the centre during the rotation of the whole instrument on its central axis, as well as during the upward and downward motion of the slider.

A very severe proof consists in sighting a distant object with the telescope, which is then reversed in its sockets, and the apparatus turned round 180°, at which the object should be intersected again by the eyepiece cross.

The immovable cross in the ocular is cut on glass, in order to prevent hygroscopical and other interruptions. For the purpose of obtaining the rectangular position of the telescope, the supporter may also be placed with one end between points, while an elevation screw is fixed to the other. The essential point for effecting the before-mentioned correction by employing the attaching or adjusting water-level consists simply in adjusting the water-level axis exactly to the leaning face by means of the correction arrangement marked *a* in the drawing. The proof is effected by reversing the angle vertically, the water-level thus turning between its points. If after the proper attachment the bubble deviates from the centre, half of this deviation must be corrected by the regulating screws of the tripod, and the other by the correction arrangement *a*. It is, however, to be mentioned that, *previous* to the above proof, the parallel position of the water-level axis towards its points of attachment is to be examined, which can effected by reversing between its two points, and thereby a deviation of the bubble, if there be any, will be removed half by the adjusting screw *b*, and the other half by the arrangement *a*. Finally, there remains the examination and correction of the water-level sideways to be made, which is done in the usual manner by the screw *c*. This attaching or adjusting water-level may also be recommended for other purposes, for instance, in mounting of machines, &c.

Regarding the peculiar construction of the aforesaid adjusting water-level, the suspension between two points, in general, it may be remarked that the same has been derived from the compensation-level constructed by F. W. Breithaupt and Son some years ago (vide Dingler's Polytechn. Journal, vol. CLIV. p. 401). In what manner this principle has been adopted in other mechanical workshops, and represented partly as an invention of their own, has been proved by an article in Carl's Repertorium, vol. IX., p. 127, by the addition of an arrangement or simplification totally at variance with the construction.

E. DIVIDING ENGINES.

248. Instrument for dividing Mathematical Scales or Rules.

H. M. Commissioners of Patents

This instrument is to be used for dividing scales according to the French, Swiss, or English measures of length, and is provided with a vernier for obtaining the smaller divisions of the scale. It can also be adapted to the production of diagonal scales.

248a. Dividing Engine, made by the late Mr. Bryan Donkin, F.R.A.S., in the year 1828.

Bryan Donkin.

The principle involved in the construction of the machine is the employment of a compensating arrangement, by which great accuracy is obtained, notwithstanding the inequalities of the screw used in the machine for advancing the cutting tool. The machine consists, first, of a table moving upon wheels on a railway. To the under side of the table is attached a clasp nut in two parts, moved by the main screw, which is below the table, and exactly parallel with the line of motion. To effect the compensation the table consists of an upper and lower plate, the upper one being capable of a small motion independent of the lower plate. The lower plate carries the fulcrum of a bent lever, whose arms are at right angles and as 50 to 1. This lever moves in a vertical plane, so that the longer arm lies by gravity alone on the undulating edge of the compensation bar. The upper plate is pressed endways against the shorter arm of the bent lever by means of a spring keeping them always in contact. By a kind of parallel motion the two plates are attached so as to allow of the very small motion required in the upper plate independently of the lower. The compensating bar, which is of the length of the screw, has 50 narrow slips of metal placed upon it, each having an adjusting screw by which the ends of the pieces may be placed in a continuous line, or above or below the line, as required by the mode of adjustment. This bar is carried by a pivot at one end, and the other end is raised or depressed by a screw, which adjusts the compensating bar to the total length moved through by the guide screw.

In the case of dividing a scale, the swing frame carrying the cutter or diamond point is attached to the framing of the machine, the scale to be divided being placed upon the upper plate.

In the case of cutting a screw, the tool holder is fixed upon the upper plate and the screw to be cut is placed between centres parallel to the motion of the table and to the guide screw, having motion imparted to it by a train of wheels connecting it with the screw of the machine. The compensating bar being adjusted for total length, and the small pieces of metal upon the same being adjusted to the intermediate errors of the guide screw, it will be seen that by the passage of the longer arm of the lever over the edge of the compensating bar, a slight motion will be imparted to the upper plate independent of the lower, so that, in other words, if by the error of the screw the lower table is moved through too great a space, the upper table is made to move (by the action of the lever) through a space equal thereto in the contrary direction, and *vice versâ.*

Note.—A description somewhat more in detail and of the manner of adjustment will be found in "Holtzapffel's Turners' and Mechanics' Manufactures," 2nd vol., p. 651 *et seq.*

Many scales were divided and many screws cut by this machine, of which some were given to various scientific friends, and Sir J. Whitworth, amongst others, had a scale and a screw about the year 1843 which have served him as standards.

265. **Machine** for **dividing right lines,** by Nicholas Fortin.

MM. Fortin Hermann Bros., Paris.

This machine is the one constructed by the celebrated inventor in 1787, and used in the works connected with the adoption of the metrical system.

The pitch of the screw is exactly one millimetre. (Fortin's machine for dividing circles, as well as this machine, was presented to the Conservatoire des Arts et Métiers by MM. Fortin Hermann Bros., in 1876.)

297. **Micrometer Dividing Machine.**

Voigt and Hochgesang (Gust. Voigt), Göttingen.

The pitch of the screw is $\frac{1}{4}$ mm., its head is divided into 200 parts; each part, therefore, corresponds to $\frac{1}{800}$ mm., reading by the vernier to $\frac{1}{10}$ of this value. By a spring fixed in the nut "loss of time" is completely removed.

The tracing appliance is constructed in the simplest manner possible. The tracing point—a diamond—is lifted by a mechanical contrivance, and let down again.

The slide allows of drawing a line of 30 millimeters in length.

The slide which carries the tracing point moves without greasing between six finely polished carnelian plates; by this arrangement any errors, which might be caused by clotted grease, will be rendered absolutely impossible.

F. Tide Registers.

327b. Patent Indicator, for tanks or reservoirs.

John Nicholas.

This gauge is similar to that last described, but the atmosphere giving comparatively a constant pressure the stand pipe can be dispensed with. The brass tube referred to in the previous description may be seen in the tank attached. It is not necessary to pierce or employ a tank when attaching one of these gauges, and the small pipes can be laid in the walls in a similar manner to gas tubes. In some cases one tube is sufficient, the water column being balanced by mercury in a metal tube at the back of the gauge. This gauge is suitable for tanks upon the roofs of mansions or hotels, where engines are used for pumping.

255. Registering Water-mark, of new construction, which records the curve of the water-level and its mean height.

Lieutenant-General Baeyer, President of the Geodetic Institute at Berlin.

Invented by F. H. Reitz, civil engineer, of Hamburg. The apparatus was made in the factory of Pape and Dennert. The clockwork is by Knoblich.

278a. Magneto-Electric Water Level Indicator.

Siemens and Halske, Berlin.

A float which rises or falls with the level of the water in the reservoir or tank communicates motion by a metallic chain to a magneto inductor, which, generating electric currents, works at any distance an indicator connected by a cable or insulated wire.

1695. Apparatus for making contact to show the height of water with float, rod-chain, counterpoise, and water tube.

C. & E. Fein, Stuttgart.

This is self-acting, and registers at any distance the water-level in a reservoir, &c.

It consists of five parts :—

(1.) The float with chain and counter-weight which when acted on by the rise or fall of the water impart their motion to the contact arrangement

(2.) The contact arrangement which communicates the motion of the float to the recording instrument by opening or closing the circuit.

(3.) The recording instrument; this shows the level of the water at all times, the pointer being acted on by the motion to and fro of two electro-magnets.

(4.) The conducting wire.

(5.) The battery.

279. Three Gauges, in enamel cast iron, for registering the height of a river or lake. *De Dietrich and Co., Niederbronn.*

The first of these on the Niederbronn pattern is in black and white and graduated to centimetres, the second on the Nancy pattern is graduated in black and white for every two centimetres, and the third on the Paris pattern is in blue and white graduated to five centimetres.

These water-mark plates are fixed by means of iron clamps to piers, vertical embankments, &c., and serve for the observation of the level of the water in rivers, canals, lakes, and reservoirs.

Placed at proper distances from one another in the chief water-courses and its tributaries, they enable the rise of the water to be observed, and consequently timely warning to be given, by telegraph or otherwise, to the inhabitants of the districts concerned.

280. Recording Tide Gauge, with self-acting indications of the mean height of the water (system of F. H. Reitz, Hamburg); executed by Dennert and Pape, in Altona.

Royal Prussian Geodetic Institute, Berlin.

The tide-measuring system exhibited by the Royal Prussian Geodetic Institution of the European measurement of a degree, at the instance of its president, General Baeyer, and constructed by Dennert and Pape of Altona, with clock by T. Knoblich, of Hamburg, has a graphic apparatus for registering the tide-curve and an arrangement by which the mean water-level is indicated automatically. The registration of the water-level is effected by means of diamond points upon a cylinder placed horizontally for the accurate division of the arc.

The mean water-level is indicated by means of two agate rollers with divisions, which slide upon a horizontal glass disc turned by the clock of the tide-measurer, moved to and fro by the rising and falling water, and by the rotation of the glass disc, and may be read off at any desired intervals of time.

The calculation otherwise necessary of the mean water-level (the true level of the sea) from the indications of the registering apparatus is saved by the above-mentioned mechanical arrangement, and effected automatically with very great accuracy by the tide-measurer.

The determination of the form and dimensions of the earth undertaken by the European Committee for re-measuring degrees of longitude and latitude, also contains the determination of the mean sea level at points on different coasts, and its comparison by means of accurate levellings. During the last few years the Committee has endeavoured, in consequence of these examinations, to study the different apparatus and to promote a more exact observation of the tide corresponding to the exact levellings recently taken.

These circumstances were the cause of a commission from his Excellency General Baeyer, President of the Central Office of the European Committee for higher geodetic purposes, and the Royal Prussian Geodetic Institution, to F. R. Reitz, instructing him to prepare a tide apparatus according to his system. The instrument now exhibited was made by Dennert and Pape, of Altona, and the clockwork by Theodor Knoblich, of Hamburgh. It is intended by the Imperial German Admiralty to place this new instrument, after the close of the Exhibition, on the Isle of Sylt, Schleswig.

The commission given by his Excellency General Baeyer referred to the construction of a new instrument, combining a registering apparatus and mechanical means of determining the mean level of the sea. The apparatus here described is therefore a combination of both objects.

A buoy A, moved up and down by the tide in a vertical shaft, turns a disc C, about a horizontal axis, by means of a copper wire B. During the ebb the wire B descends and turns the disc C; during the flood the same is effected in the opposite direction by a weight D turning the disc E, connected with the disc C upon the same axis. In order to reduce the movement of the buoy A in a certain proportion, a pinion F, on the axis of the disc C and E, moves a rack G, in a horizontal direction. On one end of G a diamond-point H is fixed, on the other end two rollers J, J, with a horizontal axis.

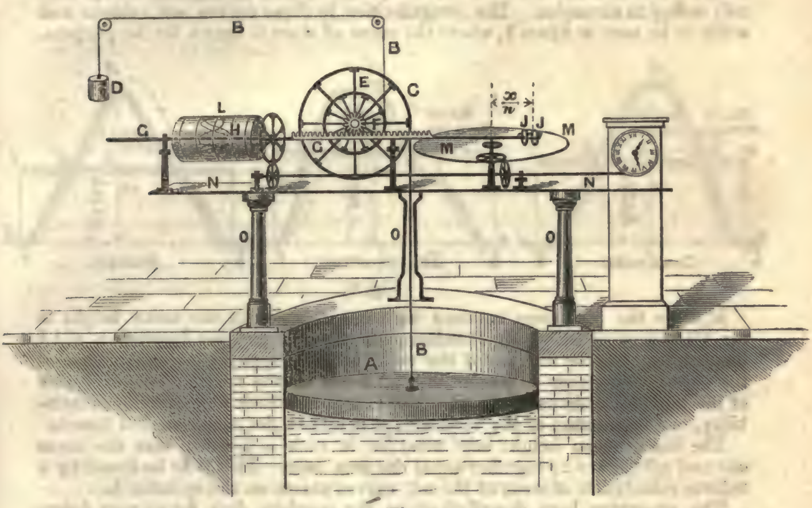


Fig. 1.

The clock of the instrument turns the cylinder round its axis in 24 hours by means of a combination of wheels, and the glass disc M in six hours.

The tide-curves are engraved upon the cylinder L with the diamond-point H. The rollers J, J move on the glass disc M by the combined action of the buoy A, the weight D, and the clockwork.

All the different parts of the apparatus are fixed upon the same plate N, N of cast iron, planed at the necessary points to insure their invariable position. The plate N rests on three columns of cast iron, placed upon the coping of the shaft.

The cylinder is covered with blackened chalk paper, whereon the diamond engraves the tide-curves as white fine lines on a black ground.

The paper on the cylinder L is divided in half hours, and from meter to meter of height. For this purpose a proper self-acting apparatus is constructed, by which both divisions are made with great exactness. Diamond-points are used for this purpose also. It is necessary, for the sake of distinctness, to renew the covering paper of the cylinder once a month. To avoid waste of time a second exactly similar cylinder is prepared and carefully divided, to replace the former cylinder.

For the observation of the constants of the apparatus, it is necessary to note complete revolutions of the disc C and glass disc M. For this purpose two indices are applied.

The circumference of the disc C, measured on the axis of the copper wire B, is exactly two meters in length.

The apparatus for the determinations of the mean height of the sea is explained by the following remarks:—

It is the question how to define the mean height of the water for a certain period.

This height would be the arithmetical mean between high and low water, supposing a regular form of the tide-curves. In fact, the real observed tide-curves differ very much from this theoretically-defined regular form (curve of sines). To show this the tide-curves of Cuxhaven, Southampton, and Ipswich will suffice as examples. The irregularities in these curves are evident and easily to be seen in figure 2, where the curve of sines is drawn for the purpose.

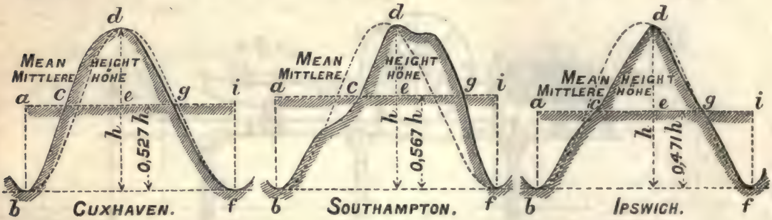
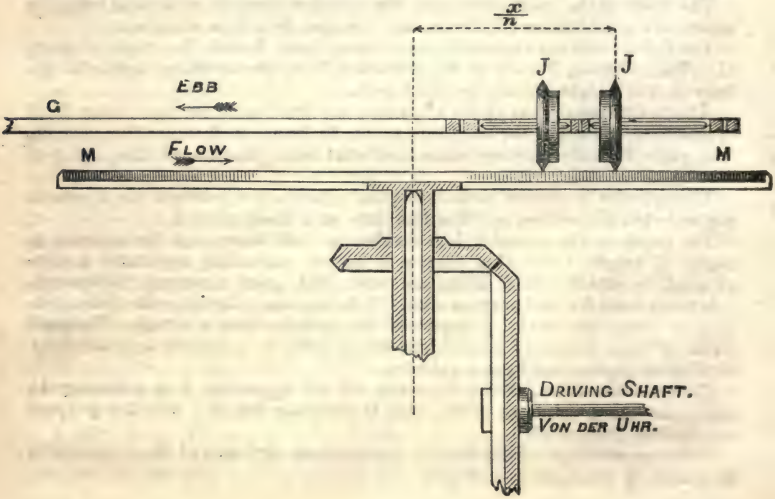


Fig. 2.

If *h* be the difference between high and low water, the mean height is for Cuxhaven 0·527 *h*, for Southampton 0·567 *h*, and for Ipswich 0·471 *h* instead of 0·5 *h*, the amount of the mean height, supposing a regular form of the curve. The mean height of the sea is one of the most important results of the tide observations. It is the only datum by which to define the invariability, or the measure of the variation, of height of the continent and islands.

The line of mean height *acgi* must be in such a position that the areas *abc* and *gfi* (figure 2) together equal the area *cdge*. This is to be found by a tedious calculation of areas of the tide-curves drawn on the cylinder L.

The apparatus here described gives the requisite data for an easy determination of the mean height by means of two rollers (JJ) (one of them con-



trolling the other) moving in accordance with the level of the water on a disc of glass (M). This disc is turned round its axis by the clockwork in 6 hours. The axis of the rollers J, J is parallel to the direction of their motion on the disc M. The number of the revolutions of the rollers is noted in certain periods by means of the divided rim (the rim is divided in 100 parts, tenths being estimated) and a numerical apparatus showing revolutions up to 100.

The height of the water may be taken from the point when the roller J stands in the centre of the disc M.

If the height of the water taken from this point be x, and the diminution of the movement of the buoy by the pinion F be $\frac{1}{n}$

$$\int \frac{x}{n}\delta\phi = \frac{1}{n}\int x\delta\phi \quad . \quad . \quad . \quad . \quad (1.)$$

is the expression for the movement of a point in the circumference of the roller J in a period during which the disc M revolves through an arc ϕ.

The expression $\int x\delta\phi$ is the area of a figure with the ordinates x and the base ϕ (x representing the height of the water and ϕ the time). The mean value of x or the height of a rectangle of equal area with this figure and the base ϕ is found by dividing by ϕ. This mean value of x is the mean height to be found, equal m suppose. Then—

$$m = n\,\frac{\frac{1}{n}\int x\delta\phi}{\phi} \quad . \quad . \quad . \quad . \quad (2.)$$

The movement of a point of the circumference of the roller J is equal to $\frac{1}{n}\int x\delta\phi$. This is equal to the product of the circumference of the roller J called p and the difference of readings on the margin of the roller J at the beginning and end of the period. Hence, if the readings are called a_1 and a_2,

$$m = \frac{n\,.\,p(a_2 - a_1)}{\phi} \quad . \quad . \quad . \quad . \quad (3.)$$

If z is the number of seconds corresponding to the arc ϕ, and b the constant arc through which the disc M revolves in a second:

$$m = \frac{n\,.\,p}{b}\,.\,\frac{(a_2 - a_1)}{z}\,; \quad . \quad . \quad . \quad . \quad (4.)$$

Finally, if $\frac{np}{b} = c$:

$$m = c\frac{a_2 - a_1}{z} \quad . \quad . \quad : \quad . \quad (I.)$$

the mean height of the sea.

The single constant c is easily to be determined by experiment and also with great exactness without the knowledge of the dimensions of the apparatus, as follows: In a certain position of the roller J a number of revolutions is made by the disc M, representing a number of seconds z_1 (a revolution is made in 21,600 seconds). At the beginning and end of these revolutions the readings (a_1 and a_2) of the roller J are noted. After this a certain length (l) of the copper wire upon the disc C is unrolled (measured by means of the circumference of the disc C, equal 2 meters, and the index, or directly). In the new position of the roller J a number of revolutions of the disc M again is made, representing a certain number of seconds (z_2), and also the corresponding two readings (a_3 and a_4) of the position of the roller at the beginning and end of these revolutions are now observed. All the requisite data for the determination of c are now obtained. If the two values of m corresponding to the two positions of the roller are m_1 and m_2 and their difference is equal l, from equation (I.),

$$m_1 = c.\frac{a_2 - a_1}{z_1}\ ; \quad m_2 = c.\frac{a_4 - a_3}{z_2},$$

therefore :

$$m_2 - m_1 = l = c\left(\frac{a_4 - a_3}{z_2} - \frac{a_2 - a_1}{z_1}\right); \text{ finally,}$$

$$c = \frac{l}{\dfrac{a_4 - a_3}{z_2} - \dfrac{a_2 - a_1}{z_1}} \quad . \ . \ . \ . \ \text{(II.)}$$

When the constant c for both rollers is calculated, the constant difference in the results for m is fixed by a number of revolutions of the disc M in the same position of the rollers. The difference of m found in this way, of course, is constant.

The equations (I.) for the apparatus exhibited, calculated as described, are :

For the roller on the left side :

$$m = 8656{\cdot}632\frac{a_2 - a_1}{z}\text{ meters.}$$

For the roller on the right side :

$$m = 8655{\cdot}983\frac{a_2 - a_1}{z}\text{ meters.}$$

The roller on the right side gives a constant difference for the value m given with the roller on the left side equal 1·3252 meter. Respecting the correction of the apparatus, it is only necessary to make the axis of the rollers parallel with the direction of the movement on the disc M. In this parallel position this movement, of course, has no influence on the revolution of the rollers. The parallel position of the axis of the rollers may be tried by experiment, by moving them on the disc M, turning the disc C. During this experiment the disc M must remain at rest. No motion of the rollers will then be observed. It seems requisite, at first sight, that the roller J move through the centre of the disc M. But this is not necessary, an approximation only being needed for practical purposes. By a sidewards position no difference in the revolution of the rollers is effected. This is proved in the following way :—

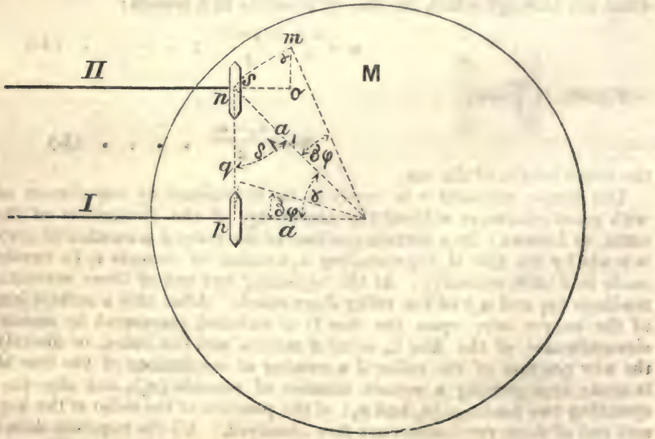


Fig. 4.

As to the two positions I. and II. of the rollers, it needs be shown that a motion $d\phi$ of the disc M causes the same effect.

In the position I. the motion of the roller is :

$$pq = a\delta\phi.$$

In the position II. the motion of the roller is not equal nm.

But:

$$mo = nm \cos j$$

consequently :

$$\cos j = \frac{a}{a_1} \text{ and } nm = a_1\delta\phi_1$$

therefore :

$$mo = a, d\phi\frac{a}{a_1} = a\delta\phi = pq.$$

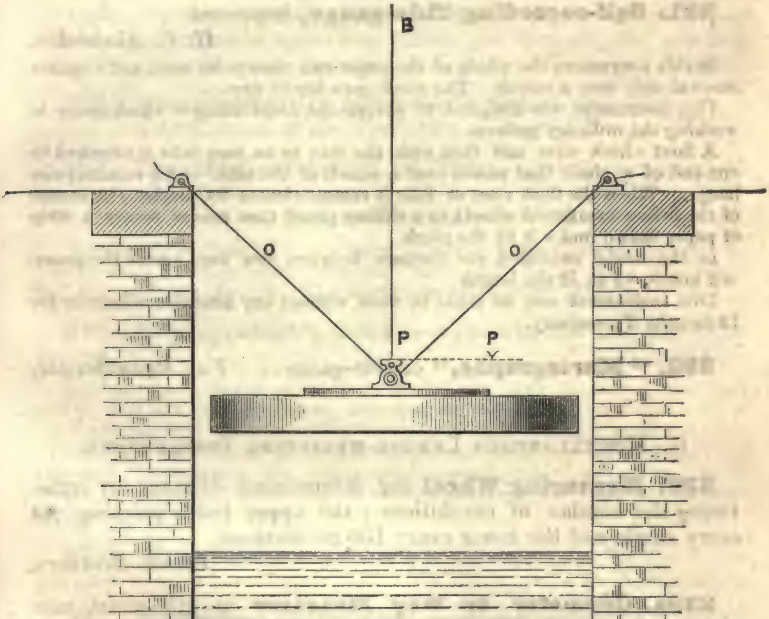


Fig. 5.

The motion of the rollers, therefore, in the two positions is equal.

To connect the distance of the points from which the mean height is measured by the instrument to a point given by levelling, the height of a point P of the buoy over the water is carefully measured.

This may be very exactly done by putting the buoy into a vessel filled with water. The buoy afterwards is lifted a little by the weight D (Figure 1). This is easy to calculate from the area of the buoy, the weight D, and the radius of the discs C and E. The buoy then is fixed at a certain height by a wire O. In this position the height of P. below a point given by levelling is carefully measured. The absolute height of the water represented by the chosen position of the buoy is now known. After this the mean height corresponding to the same position (viz., the constant height of this position) is calculated according to the result by a number of 10 or more revolutions of the disc M. If the measured height corresponding to the position of the buoy be equal h, and if the height given by the instrument be equal m, $h-m$ is the absolute height (according to the levelling) from which the mean height given by the instrument is taken.

The diamond-point can then be fixed in a position to get a corresponding diagram on the cylinder L to the absolute height given by levelling.

F. H. Reitz,

Hamburgh, May 1876. Civil Engineer in Hamburgh.

281. Self-recording Tide-gauge, improved.

H. C. Ahrbecker.

In this instrument the whole of the paper can always be seen, and requires renewal only once a month. The clock goes for 32 days.

This instrument was designed to obviate the disadvantages which occur in working the ordinary pattern.

A float which rises and falls with the tide in an iron tube is attached to one end of a chain that passes over a wheel, at the other end a counterpoise hangs. When the float rises or falls it communicates its motion (by means of the before-mentioned wheel) to a sliding pencil that moves across a strip of paper drawn under it by the clock.

In the model exhibited the distance between two lines across the paper, =2 hours, =1 ft. in the length.

This instrument can be made to work without any attention whatever for 12 months if necessary.

282. "Maréegraphe," or tide-gauge. *Van Rysselberghe.*

G. Miscellaneous Length-measuring Instruments.

238. Measuring Wheel for determining distance by registering the number of revolutions; the upper index pointing out every single and the lower every 100 revolutions.

Elliott Brothers.

238a. Odometer or Way Measurer in gilt metal case elaborately chased, an early example, probably made in the second half of the 16th century. *Alexander Nesbitt.*

In Beckmann's History of Inventions there is a description of two instruments resembling this, which belonged to the Emperor Rudolph II. (1576–1612).

415b. Fare and Distance Indicator for Street Cabs.

Robert Foster, Sunderland.

This is an instrument for measuring the distance travelled by a cab or other vehicle to which it may be attached. A driving band taking its motion from the road wheel actuates counting wheels, and so pointers are made to indicate on dials the distance passed over and the fare. There is also an appliance for registering on a slip of paper all the fares taken during the day. The pointers can be brought back to zero by the driver, but they cannot be moved forward except by the motion of the vehicle.

240. Improved Measuring Wheel or Mile Meter.
Elliott Brothers.

240a. Micrometrical Divisions in English and Metric Measure. *Dumoulin Froment, Paris.*

270. Holt's Diagrammeter. This instrument is specially made for measuring the ordinates of indicator-diagrams 5″ long, and is used much after the manner of a parallel rule, the registering nut on the screw being first placed at zero; when it is required to register a measurement the break key is depressed, and when all the measurements have been taken the distance the nut has travelled gives the mean ordinate. *Henry P. Holt.*

274. Spherometer (by Salleron), to read to ·001 mm.
The Council of the Yorkshire College of Science, Leeds.

276. The Wealemefna, E. R. Morris's patent.—A pendant for the watch-chain.
The Morris Patents Engineering Works, Birmingham.

To measure, it is merely necessary to advance the Wealemefna over the object, when the large hand will register the inches and fractions of an inch, and the small one the feet. The instrument registers to 25 feet.

276a. Schlagenheit's Measurer for Curved and Straight Lines. *S. J. Hawkins.*

This instrument has a small wheel A, the periphery measuring one inch and divided into five equal parts, indicated by fine points, marking when in use each length by a slight indentation upon the map or plan. At each revolution of the wheel a small spring B is struck, indicating that one inch has been traversed. Attached to the instrument is a small scale C, ⅕th of an inch in length, divided into 10 parts for measuring distances less than one division of the wheel.

276b. Opisometer. Instrument ordinarily used for the above purpose. *S. J. Hawkins.*

277. Measuring Instrument, E. R. Morris's patent. (Silver medal awarded at Manchester, 1875.) For the use of architects, surveyors, builders, contractors, timber merchants, &c., &c., and for general measuring purposes, in place of the rule or tape. It measures to 100 ft., and weighs under 3 oz.
The Morris Patents Engineering Works, Birmingham.

To use the instrument it is merely necessary to advance it along the object to be measured, when the large hand will register the inches and fractions of an inch on the outer dial, the smaller hand on the inner dial, the feet and the smallest hand on the recessed dial, the tens of feet travelled over. The instrument registers to 100 feet. Price, electro-silver, in leather case, 16*s.* 6*d.*

278. Chartometer, E. R. Morris's patent. (Silver medal awarded at Manchester, 1875.)

The Morris Patents Engineering Works, Birmingham.

The only instrument that measures and registers distances on maps, plans, scaled drawings, &c., and that is adapted for various scales. By guiding the small steel wheel along any route on a map, the hand registers the actual distance in miles, yards, &c., according to the dial in use and the scale of the map, which should correspond. To deal with a map of a difficult scale, the glass front is opened by pressing a spring; the dial removed, and another corresponding to the fresh scale slipped into its place. A set of dials adapted to the scales of all the Ordnance maps, and the usual scales of travelling maps, &c., &c., is contained in a recess of the leather case, beneath the instrument.

277a. Pedometer, of the latest and most approved form.

J. and W. E. Archbutt, Westminster.

This instrument has pendulum action, and is worn suspended in the waistcoat pocket; it is provided with a regulator whereby it can be set to accurately record distances walked.

277b. Improved form of Pedometer, by Dollond, in which the direct chain action is substituted for the lever; made in the early part of the nineteenth century.

J. and W. E. Archbutt, Westminster.

277c. Pedometer or instrument for accurately registering distances walked. This instrument was invented and made by Spencer and Perkins in the latter part of the eighteenth century. *J. and W. E. Archbutt, Westminster.*

290. Scale for Measuring Curves, Eschenauer's patent.

Hermann Schäfer, Darmstadt.

The curve scale is intended for engineers, steam boiler makers, surveyors, architects, and others, for copying maps, plans, &c.

It will be of great advantage in the projection of railway lines, the curve scale requiring only to be adjusted to the situation in order to ascertain how the line can be most favourably traced, and expensive cuttings avoided. In regard to such surveys, as well as in the control or examination of railway lines already traced and sketched (for which purposes either the curves, cut of certain radii, or compasses, are used at present), the employment of the curve scale will save the trouble of trial, since the correct one can be immediately determined and read by means of this instrument.

Boiler manufacturers, also, and almost all engaged in technical pursuits, will find the curve scale very useful for determining the radius of an arc of a circle, of which three points are given, as, for instance, in curved steam boiler bottoms.

In fact, in all cases where part of an arc of a circle, or three points of the same; are given, the radius can be read direct, and without loss of time, in a manner hitherto unknown.

If it be desired to take the radius of a given curve by means of the scale, the middle bar of the same is placed on the curve line, and the scale is then moved so far upwards or downwards until the curve line meets in three commensurably described points of the scale. The number indicated gives the radius of the curve in centimeters, if the curve is drawn in its natural size.

If, however, the drawing of which the radius of the curve is to be determined is, as is usually the case, on a reduced scale, the radius indicated must be multiplied with the proportional number of the reduced scale.

For example, if the drawing should be to the scale of $\frac{1}{2500}$ of the natural size, and the curve radius on the curve scale is indicated with 52·5 cm., the actual radius of the curve will be $52 \cdot 5 \times 2{,}500 = 131{,}250$ cm., or 1,312·5 meters; or, should the drawing be to the scale of $\frac{1}{500}$, and the curve scale indicates 43 cm., the radius of the curve will be $43 \times 500 = 21{,}500$ cm., or 215 meters.

The curve scale can likewise be used as a reduction scale of every other measure which is to be calculated in meter measure, as the radius in meters can always be read directly, no matter in what scale the drawing is made.

This is a great saving of labour, which is very much facilitated if, as often is the case, old maps and drawings are to be made use of.

In using the curve scale it will sometimes happen that the curve to be ascertained does not exactly meet the line drawn on the scale, but will fall between two lines. In this case the smaller division can, as the radii are marked progressively by 0·5 cm., be easily estimated by eye after a little practice.

For example, the curve of the radius of 1,110 meters, at a proportionate scale of $\frac{1}{2500}$, lies between 88·5 and 89·0 of the curve scale, and amounts to nearly 88·9.

As, however, in most cases, round numbers, without fractions, are chosen for the radii, the radius can always be determined with the greatest accuracy.

1093a. Ellipsometer.

Before the eyepiece of the glass, a double refracting prism is made to turn until a wire, moving perpendicularly to the principal section of the prism, passes through the two intersecting points of the two reflections of the ellipse. An index shows at the moment the position of the prism.

Graphometer of Botti.

The Royal Institute of "Studii Superiori," Florence.

III. MEASUREMENT OF AREA.

316. Amsler's Planimeter, for calculating with perfect accuracy the areas of plans, maps, or other plane surfaces, in square inches and metrical measure. *Elliott Brothers.*

317. Polarplanimeter. *Ott and Coradi, Kempten, Baviera.*

By means of the polarplanimeter the superficial contents of any kind of figures drawn on paper, no matter what their outline may be, can be ascertained by mere tracing more exactly and quickly than by any other method.

The inventors of this instrument are respectively J. Amsler, Schaffhausen, and Ch. Starke, Vienna. Ott and Coradi's construction is a combination of both, embracing the excellences of each. It differs from Amsler's instrument by the pole (axis) of the instrument not being formed by an inserted point of a needle, but by a steel ball embedded in a metal cylinder, thus giving it a firmer position; and, moreover, by the axis of the roller being lodged in a horizontal frame, and the dividing circle of the roller as well as the indicating wheel being free at the top, thereby affording much easier and more accurate reading than Amsler's instrument. This arrangement has the advantage that for simple calculation the zero point of the roller can be placed exactly on the zero point of the vernier, when the tracing pencil is at the commencement of the figure. The weight can be separated from the instrument, by withdrawing the bolt, and placed in the case by itself. The runner carrying the axis of the polar arm can be moved along the whole length of the quadrangular bar, by which means at every longitudinal scale desired a round number can be obtained for the value of the vernier unit (for example, scale 1·500 vernier unit, 2 square meters, or scale 1·1440 vernier unit, 5 square fathoms). The tracing bar is divided into ½ mm., and the runner sliding on the same carries on one side a vernier, on the other an index. For adjustment with the index, the most usual or specially desired longitudinal scales are marked with lines on the bar; by means of the vernier and the divisions on the bar, proportions of measure not previously given can be easily inserted and noted down; in the same manner, in the case of plans which have been drawn on shrunk paper, the area can be retained in its actual size by a corresponding movement of the runner, and the position of the vernier noted down for a certain amount of shrinking.

318. Planimeter, divided on a glass plate.

F. W. Breithaupt and Son, Cassel.

The planimeter consists of a network marked on a glass plate for a certain scale of the meter measure.

319. Wetli's Planimeter.

Physiological Institute of the University of Halle (Prof. Bernstein, Director).

The planimeter is fitted together by placing the six-toothed movement into the centre of the divided disc, whilst the central point of the small glass disc moves at the other end in the screw of the ring encircling the divided disc. Next, the slide with the large glass disc is placed on the three-railed track in such a manner that the horizontal glass disc comes underneath the smaller vertical one; the latter is then, by means of the screw which is fixed on the ring, regulated in such a manner that it is easily carried along with the horizontal disc by friction.

The pointer moving on the same axis with the divided disc indicates the superficial contents of the figure in square millimeters. The small toothed wheel records every 1,000 square millimeters of the surface.

IV. MEASUREMENT OF VOLUME.

Standard Measures.

319a. Casts of a Collection of Roman Measures to hold liquids.

Archæological Museum, Madrid.

The originals, of alabaster, are preserved at the Archæological Museum of Madrid. They were discovered at the end of the last century in the Torre del Mar, Province of Malaga, Spain.

322a. Series of Standard Measures of Capacity, in copper, with glass discs, from the centilitre to the double decalitre. (11 measures.)

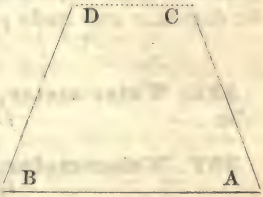
Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

324. The Standard Pint, popularly known as "The Stirling Jug." *The Smith Institute, Stirling.*

This measure was entrusted to the town by Act of (the Scottish) Parliament, in the year 1437. Sometime previous to 1745 it had been borrowed by a coppersmith for the purpose of making others, and as he joined the insurgents in "45" it was lost sight of. On his not returning, his effects were sold, with the exception of a few that were thrown into a garret as rubbish; among these, in 1752, the Stirling Jug was found, after some years of patient and unwearied search (by Rev. A. Bryce, of Kirknewton). It is made of brass, and is in the shape of a hollow truncated cone, weighing 14 lbs. 10 oz. 1 dr. 18 grs. Scottish troy. Diam. of mouth 4.17 English in., of the bottom 5·25 in., and depth 6 in. On the front, near the mouth, is a shield in relief, bearing a lion *rampant*, the Scottish national arms, near the bottom is another, bearing an ape *passant gardant*, supposed to be the arms of the foreign maker.

324a. Russian Standard Measures of Capacity (Vedro, $\frac{1}{2}$ V., $\frac{1}{4}$ V., $\frac{1}{10}$ V., $\frac{1}{100}$ V.). *Siemens and Halske, Berlin.*

These measures, made of bronze, have a conical shape, newly adopted in Russia, for standard and trade measures of capacity. In these measures the inner diameter, A B, of the bottom is equal to an inner side, A C, and double diameter, C D, of the orifice. By very simple contrivance, such trade measures might be verified, approximately, by (linear) measurement of A B, A C, and C D.



325. Set of Standard Measures for Alcohol, conical shaped, in order to diminish the possibility of evaporation of the liquid. *Siemens and Halske, Berlin.*

322. Measures of Capacity, according to natural principles.

Hans Baumgartner, Basle.

WATER METERS.

321. Schmid's New Water Meter. *A. Schmid, Zürich.*

This meter consists of two of Schmid's patent hydraulic motors, coupled at right angles, and enclosed in a water-tight casing. They are set in motion by the force of the fluid they have to measure. At each revolution a volume equal to the contents of four cylinders must pass. The pressure required to keep tight the oscillating surfaces of the cylinders is furnished by the difference of pressure at inlet and outlet, which is thus self-regulating. The meter is also kept in motion by the difference of pressure. The frictional resistance is the same with all pressures of the fluid under measurement, and, according to the size of the meter, is represented by a water head of 3 to 16 ft. The different parts of the meter are constructed of materials not liable to chemical influence.

The chief advantages of this meter are :—

1. The velocity of the engine is exactly in proportion to the quantity flowing through the meter.
2. According to the most careful experiments, the error, if any, does not exceed 1 per cent.

321a. Siemens' and Adamson's Patent Water Meter.

Guest and Chrimes, Rotherham.

This meter has a great resemblance to the motive-power machine known as Barker's Mill. The water passes down through a funnel into the measuring drum, and in passing outward through the curvilinear channels of the same causes it to revolve, delivering a certain quantity of water at each revolution of the drum, and this is indicated by worm wheel and gearing, in gallons, feet, or any other units required, on a dial plate properly divided and prepared for the purpose.

The meter is exhibited in section, so that the internal arrangements and its action can be seen. This meter has been extensively used for upwards of 20 years.

321b. Half-inch Patent Water Meter, for the water supply for domestic and trade purposes on the constant supply system.

J. Tylor and Sons, London.

326. Water-meter, for cold water, for 26 mm. width of tube. *Dreyer, Rosenkranz, and Droop, Hanover.*

327. Water-meter, for domestic use.

Dreyer, Rosenkranz, and Droop, Hanover.

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331. Model of a Gas Meter of ancient construction, with glass sides.

School for Industry, Halle (Dr. Kohlmann, Director).

329. Apparatus for determining the capacity of Cartridge-cases as far as 20 cub. mm. *A. Bonsack, Berlin.*

330. New Volumeter, consisting of A. Sauer's burette, a second glass piece, stands and tubes.

(Compare Fresenius, "Zeitschrift für analytische Chemie," xiv. heft. 3 and 4).

Berggewerkschafts-kasse, Bochum, Dr. Heintzmann.

V. MEASUREMENT OF MASS.

A. BALANCES.

333. Balance, with double column, 20-inch beam, fitted with steel knife edges working on agate planes, to carry 5 lbs. in each pan, and turn distinctly with ·01 grain. Fitted with apparatus for moving sliding weight without opening glass case. As made for the Warden of Standards, for comparison of standard weights. *L. Oertling.*

334. Balance, with double column, very light beam, 10 inches long, fitted with agate knife edges and agate planes, to carry 30 grains in each pan, and turn distinctly with ·001 grain, with apparatus for moving sliding weight. *L. Oertling.*

335. Balance, with 14-inch beam, fitted with agate knife edges and agate planes, to carry 1,500 grains in each pan, and turn distinctly with ·001 grain. *L. Oertling.*

336. Balance, with 16-inch beam, fitted with agate knife edges and agate planes, to carry 2 lbs. in each pan, and turn distinctly with ·02 grain. *L. Oertling.*

337. Balance, with triangular beam, 6½ inches long, fitted with agate knife edges and agate planes, to carry 3,000 grains, and turn distinctly with ·01 grain. *L. Oertling.*

338. Balance, with beam 6½ inches long, fitted with agate knife edges and agate planes, to carry 2,000 grains in each pan, and turn distinctly with ·02 grain. *L. Oertling.*

339. Portable Assay Balance, with 6-inch beam, to carry 30 grains in each pan, and turn distinctly with ·001 grain. *L. Oertling.*

340. Balance, constructed by H. Olland, of Utrecht, to weigh bodies up to 40 kilogrammes. *Prof. Dr. P. L. Rijke, Leyden.*

This instrument is furnished with a double system of "fourchettes," directed by a rod 0·6 m. long. A difference of 1° in the pointer corresponded to a difference in weight of—

9·5	m. gr.	when the weight was	20	kilogrammes.
10·5	„	„	50	„
13·8	„	„	73	„

With weights of about 50 kilogrammes, in a series of experiments under favourable conditions, between each of which the balance was set at rest, numbers not differing in the average by more than 0°·03 were obtained. When conditions were less favourable, the differences amounted to 0°·26, and only reached 0°·94 when the conditions were altogether unfavourable.

341. Analytical Balance, charge up to 500 grammes in each pan; sensible to $\frac{1}{10}$ part of a milligramme with its full charge.
Beckers Sons, West Zeedyk, Rotterdam.

This balance is furnished with agate knife edges, and all bearings rest on agate planes; it has a rest for pans and beam, and apparatus with adjustable shelf for taking specific gravities. The beam is divided in $\frac{1}{10}$ parts of a milligramme. Sets of weights from 500 grammes down to 1 milligramme. Three riders.

342. Analytical Balance, on plan suggested by Professor Dittmar, Andersonian University, Glasgow, for a charge up to 100 grammes in each pan.
Beckers Sons, West Zeedyk, Rotterdam.

This instrument shows a new method for displacing the centre of gravity of the beam, and for weighing up to 110 milligrammes by means of riders. The two riders form a part of the balance, with plunger for displacing exactly 10 grammes of water at 15° C. for taking specific gravities of liquids. Sets of weights.

343. Balance, with drawer and eccentric for lifting, movable pans, set screws and level, charge up to 1½ kilos. in each pan, sensible for 20 milligrammes with its full charge.
Beckers Sons, West Zeedyk, Rotterdam.

344. Balance, charge up to 1 kilo. in each pan, sensible for 20 milligrammes with its full charge.
Beckers Sons, West Zeedyk, Rotterdam.

344a. New description of Balance of Precision, designed by M. Mendeleef, Professor of the University of St. Petersburgh, and constructed by Oertling. It is more particularly described in Appendix 10 to the Ninth Annual Report of the Warden of the Standards. *H. W. Chisholm.*

The peculiarity of this balance is that it has very short arms, and thus occupies very little room, and by its more rapid motion time is saved in weighings, whilst it gives results quite as accurate as those given by balances of precision with arms of greater length as ordinarily used.

Though constructed to carry a kilogram in each pan, the total length of the beam of this balance is less than 4¾ inches, whilst it is intended to give results within one tenth of a milligram. The balance beam to carry a kilogram is ordinarily 20 inches in length.

It can be used as a vacuum balance, as well as for weighings in air.

344b. Balance of Precision for minute weighings of 10 grains and under in each pan, constructed by Oertling.
H. W. Chisholm.

The beam is made as light as possible, and unusually so. The pans and suspending wire are of aluminium. The balance works upon fine points. A single action lowers the support of the beam and the supports of the pans.

348-9. Frerich's analytical **Balance,** capable of carrying 2,000 grms. with riders and a set of gramme weights.
F. Sartorius, Göttingen.

350. Analytical Balance, capable of carrying 500 grms., and a set of gramme weights. *F. Sartorius, Göttingen.*

351. Analytical Balance, capable of carrying 200 grms., with a set of gramme weights. *F. Sartorius, Göttingen.*

352. Frerich's Analytical Balance, with contrivance for weighing by means of torsion. *F. Sartorius, Göttingen.*

353. Pair of Russian Scales. *Bennet Woodcroft, F.R.S.*

354. Test Balance capable of carrying 20 grammes in each scale. *Edouard Sacré, Brussels.*

The bearings are taken off the knife edges when the balance is at rest. With 20 grammes the balance is affected by the 750th part of a milligramme. With 2 grammes it is affected by the 7,000th part of a milligramme.

354a. Model Balance, with two columns, specially intended for verifying the standard kilogram weights, mounting and tongue of aluminium bronze, tires and scales of aluminium, riders, carriage for shifting the weights from one scale to the other, rests for four weights, rules for the use of small sliding weights replacing the divisional series of the gramme, such as the decigramme, centigramme, milligramme, 10th of milligramme, hand of aluminium with double dial, parallel mirror for reading the oscillations at a distance, spherical level, two "Baudin" thermometers.

Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

354b. Model Balance, with two columns, charge 300 grammes range, for chemical analysis, mounted on cast-iron tripod, mounting and tongue of bronze, platina tires, riders showing tenths of the milligramme, spherical level.

Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

357. Printing Beam for Weighing Machine, admitting of the registration of each weighing. *M. Chameroy, Paris.*

This method of checking is applicable to all weighing machines of the nature of the steelyard. It would be found useful at custom houses, depôts, markets, railway stations, works, and other similar places.

Its advantages are :—

1. The affording of a record, by means of a printed impression on a special ticket, of the exact amount of the weight as determined by the machine itself.
2. The facilitating of the reading of the weights, either on the ticket or on the scale beam.
3. The preservation of an exact record of weighings, the authenticity of which is thus ensured.

358. Physical Balance, weighing up to five kilogrammes.

Hugo Schickert, Dresden.

359. Physical Balance, weighing up to 200 grammes.
Hugo Schickert, Dresden.

363. Fine Assay Balance for weighing 20 grammes, turning with 1/100 mg. *G. Westphal, Celle.*

364. Large Balance for determining the specific gravity of liquids. *G. Westphal, Celle.*

365. Large Balance used in the **Manufacture** of **Sugar.**
G. Westphal, Celle.

366. Small Balance for determining the specific gravity of liquids. *G. Westphal, Celle.*

367. Pharmaceutical Balance, for simple chemical operations. *G. Westphal, Celle.*

370. Balance for chemical and physical purposes.
C. Staudinger and Co. (F. W. von Gehren), Giessen.

Balance of the exhibitors' construction; capacity of weighing, one kilogramme on each scale; sensitive at this weight, to 0·4 milligr. The balance is made of one piece of wrought (not cast) brass, and gilded. The centre and terminating knife edges are of steel, and all supports of hard stone. The weight of the beam with knife edges is = 793 grammes; deflexion of the beam at 1 kilogr. weight on each scale = 0·14 mm.; at 1·500 kilo. weight = 0·028 mm.; at 2·000 kil. weight = 0·042 mm.; at 3·000 kil. = 0·070 mm. A permanent deflexion has not been observed at such a weight.

375. Ten Plates of Rock Crystal for Balances.
Hermann Stern, Oberstein.

376. Chemico-physical Balance, executed by Ch. Jung, in Giessen.
Collection of Physical Instruments of the University of Giessen (Prof. Dr. Buff).

By shortening as much as possible the beam these scales offer the advantage of great sensitiveness and sufficient rigidity to weigh accurately from 250 grammes to $\frac{1}{10}$ milligrammes.

377. Analytical Balance, executed by Stollenreuther.
University of Munich.

379. Standard Weights in Glass, executed by Stollenreuther. *University of Munich.*

381. Model of a Balance for determining the quality of grain, constructed according to the directions of the Imperial German Commission for Standard Weights and Measures, with a corn measure of 1 liter capacity. *Reinhold Löhmann, Berlin.*

The manner of adjusting the several parts, as well as the successive series of applications of the same, is illustrated and facilitated by an explanation, with sectional and cross-sectional drawings, accompanying the model.

The practical employment and use of the apparatus for scientific and technical industries, in the first instance, and next for the solution of national-economical problems, will be demonstrated by two continuous memoirs, published by the Imperial German Commission on Normal Weights and Measures.

381a. Corn Balance, in box for showing the per-centage in value of corn by weight as a means of fixing the price for purchase or sale. *L. Casella.*

382. Model of a Centesimal Weighing Machine, with glass platform. *Dr. Kohlmann, Halle.*

384. Model of a Decimal Weighing Machine, with glass platform.

Physical Institute of the University of Halle (Prof. Knoblauch, Director).

386. Beam Balance with equal arms, sensibility 1 : 200,000.
Kleemann, Mechanical Engineer, Halle.

390. Beam Balance, for educational purposes.
Alex. Bernstein and Co., Berlin.

The beam, for educational purposes, has contrivances for demonstrating the different peculiarities of a scales-beam, or balance, namely, displacement of the centre of gravity, lifting and grinding of the principal bearings, unequal lengths of levers, non-parallelism of the knife edges, and position of *one* terminal knife edge out of the level of the two other knife edges.

388. Small Decimal Balance, for educational purposes.
Alex. Bernstein and Co., Berlin.

The decimal balance for instruction in schools has on each prism a scale, so that the influence of the weight on each prism can be shown by itself.

389. Analytical Balance.
Alex. Bernstein and Co., Berlin.

This analytical balance is capable of carrying 500 grammes, and when fully weighted has a sensitiveness of $\frac{1}{10}$ mgr.; it has a perforated gilded brass beam with axes of agate and pans with arrangement for releasing all knife-edges, stop balance with pencil, and riders.

389a. New Balance for a Laboratory, carrying three kilogrammes in each pan, and turning with five milligrammes.
Deleuil, Paris.

When it is not in use, the beam is supported free of the knife edge, as in other accurate balances; vessels 25 centimetres in diameter can be placed on the pans, also vessels with long necks, and flasks of 1-2 litres capacity. By the aid of the second pan, the specific gravity of very bulky bodies can be obtained.

389b. Balance in mahogany case.
Universitäts Laboratorium, Berlin.

390a. Self-Acting Balance for Galvanic-plastic purposes. *Alex. Bernstein and Co., Berlin.*

The balance for galvano-plastical purposes is so constructed that the conduction is interrupted automatically as soon as a deposit of a certain weight has been obtained.

391. Balance for Blow-pipe Experiments, in a case with weights. *Alex. Bernstein and Co., Berlin.*

The scales are for blow-pipe experiments; they have steel axes, and agate planes, two horn pans, two pairs of small gilded bowls, one bowl with hook for the determination of specific gravities, and a set of weights from 1 gr. to 1 centigr. of silver; from 1 centigr. to 1 milligr. of aluminium, and the fraction milligr. of quills.

392. Gold Assay Balance.
Alex. Bernstein and Co., Berlin.

The gold-alloy scales have a carrying capacity of 5 grammes, and are provided with bearings of agate, and indicate, when fully weighted, $\frac{1}{20}$ milligr.

378. Balance for Weighing in Vacuo, on von Jolly's principle. *University of Munich.*

392a. Bullion Scales. The property of the Conservatoire des Arts et Métiers, 1866; constructed by Baron Séguier.
The late Baron Séguier, Membre de l'Institut.

419a. Spring Balance, with arrangement for suspending the lever and the scales on steel springs.
Physical Institute of the University of Halle (Prof. Knoblauch, Director).

428. Von Jolly's Spring-balance. *University of Munich.*

B. STEELYARDS.

332. Roman Steelyard or Statera, of bronze. It was found in the year 1855, during building operations at Watermoor, a suburb of Cirencester, Gloucestershire.
Professor A. H. Church.

The beam, which is nearly 17 inches long, may be reversed, and it is consequently divided along both its upper and under edges. When the fulcrum nearer the head of the beam is employed objects can be weighed more than twice as heavy as those which can be accommodated when the beam is suspended by the other hook. To the head of the beam is attached a chain, branching below into two parts, each terminated in bold hooks adapted for grasping soft and bulky articles. This steelyard is a very good example of its kind. The locality which furnished it was the site of the Roman city of Corinium or Durocornovium, which has yielded an immense number of Roman remains, many of which are preserved in the local museum.

383. Model of a Roman Balance, with sliding weight of 75 grammes, and stand.

Physical Institute of the University of Halle (Professor Knoblauch, Director).

C. WEIGHTS.

346. Five Standard Weights derived from the polar standard of length. *Prof. Hennessy, F.R.S.*

One of these weights is equivalent at 15° centigrade to a cube of distilled water whose side is the one hundred millionth part of the earth's polar axis. The others are submultiples of this weight, and the system is suggested in connexion with the polar standard proposed. *See* "Essay on a Uniform System of Weights, Measures, and Coins of All Nations," by Professor Hennessy.

346a. Series of Massive Copper Weights, standards of 1 gramme up to 20 kilogrammes, with subdivisions in platina. "Nécessaire" for inspector of weights and measures on his rounds, weighing about 10 kilos., and containing every requisite for testing scales, of weights, measures of capacity, and of length, and apparatus for stamping.

Messrs. Collot Brothers, Boulevard de Montrouge, Paris.

346b. Ancient French Standard Weight of the city of Rouen, of brass, in the form of a series of cup weights in a closed box of ornamental shape, weighing altogether 8 lbs. of the old poids de marc de Charlemagne. Presented to the Standards Department in 1869 by Colonel Le Contens, Viscount of Jersey.

H. W. Chisholm.

346c. Weight, wrought iron, ornamented with arabesques. flowers, and masks. Made for the old Mint at Madrid in the 17th century by the iron-master *Salinas.*

Archæological Museum, Madrid.

360. Physical Weights. *Hugo Schickert, Dresden.*

361. Eight Sets of Weights, for analytical purposes.

G. Westphal, Celle.

The first of these weighs from 1 kilogramme downwards, the second from 500 grammes downwards, the third from 100 grammes, the fourth, fifth, and sixth from 50 grammes, the seventh from 10 grammes, and the eighth from 0·5 grammes downwards.

362. Standard Weights. Each weight consists of one piece of solid metal adjusted by the gilding process.

G. Westphal, Celle.

These consist of a 1 kilogramme weight, a set of weights weighing from 1 kilogramme downwards, and a set of standard weights with pin adjustment weighing from 500 grammes downwards.

362a. Box of Weights, containing two kilos. and fractions of a kilo. *Deleuil, Paris.*

362a. Case of Weights and Measures. *T. Oertling.*

'Containing—

Set of weights from 1 kilogramme to 1 milligramme.

Set of weights from 50 grammes to 1 milligramme.

Set of weights from 1,000 grains to $\frac{1}{100}$ grain.

Set of weights for assaying silver, 1,000 = 1 gramme, in circular ivory box.

Sets of weights of rock crystal (one spherical set), from 50 grammes.

Set of measures from ½ litre down.

Sikes' hydrometer, as supplied to the Honourable Board of Inland Revenue.

Bates' saccharometer, as supplied to the Honourable Board of Inland Revenue.

Set of petroleometers for testing liquids of 650 to 900 specific gravity.

262b. Iridio-Platinum Standard Kilogram. *Johnson, Matthey, and Co.*

323. Standard Weights, according to natural principles. *Hans Baumgartner, Basle.*

374. Sets of Weights and single Weights from 1 kilogramme, made of rock-crystal; amongst them some which have been examined and marked with an index error by the Imperial Commission for regulating Standard Weights and Measures at Berlin. *Hermann Stern, Oberstein.*

The weights, as well as the measures of quartz or rock-crystal, were many years ago recognised as the best and most correct; but no one has, up to this time, executed them in such a manner as to afford institutes an opportunity of procuring them; which want has now been supplied by the exhibitor.

The other objects of agate are such as are produced by the Oberstein-Idar grinding and polishing mill, and can be employed in different kinds of machinery.

374a. Series of Spherical Standard Weights in Quartz, from 1 kilogramme to 1 milligramme. *A. Hilger.*

374b. Standard Kilogramme Weight, quartz sphere, on brass stand. *A. Hilger.*

374c. Standard Kilogramme Weight, of guaranteed value 1·0000019 kilo. *A. Hilger.*

387. Set of Pharmaceutical Weights from 0·01 grammes to 200 grammes (19 pieces). *Kleemann, Mechanical Engineer, Halle.*

Representation of the Weights and Measures used in the time of Henry VII., as well as the mode of punishment of fraudulent traders, copied from a painting on panel of the period (doubtless official). *Gardner Collection.*

D. INSTRUMENTS FOR DETERMINING SPECIFIC GRAVITY.

347. Tangential Balance for measuring the density of liquids and solids by the angle of inclination, read on a divided circle to two minutes, thus giving the third decimal of specific gravity ; made by Oertling, of London.

Prof. Carl Wenzel Zenger, Prague.

355. Hydrostatic Balance, by Ramsden ; with **Weights,** by Robinson, presented to the Royal Society by Lady Banks.

Royal Society.

368. Xylometer (cylindrical form), with brass cylinder.

Zimmer Brothers, Stuttgart.

369. Xylometer of Glass, prismatic form.

Zimmer Brothers, Stuttgart.

These instruments are chiefly used in the management of forests, and for agricultural purposes.

They are employed for exact scientific examinations, especially for the cubing of irregularly-shaped pieces of wood, and for determining the specific gravity of wood.

Discs of wood which have been split out from the heart in the direction of the pith rays, and therefore contain proportionate parts of all veins of wood, can be quickly and exactly examined.

With both apparatus it is possible to read on the scale accurately down to 5 cub. centimeter (5 grammes water).

(See " Holzmessekunst," by Prof. Dr. Baur, Hohenheim.)

425. Hydrostatic Apparatus for ascertaining the specific gravity of woods.

Prof. Dr. Nördlinger, Hohenheim, Württemberg.

372. Densimeter of Major Bode's construction, for determining the specific gravity of all sorts of powder.

A. and R. Hahn, Cassel.

The densimeter is the only existing instrument with which the specific weight of all sorts of gunpowder (prismatic powder, powder-cakes, fine and coarse grained powder, &c.), can be easily determined, in quantities of 50 to 250 grammes, with the most perfect accuracy.

It is constructed by Major Bode.

This apparatus consists of a reservoir with bolt, two gutta-percha tubes, and a clamp.

1. The reservoir is formed by a steel capsule, with lid fitting air tight.

By means of the bolt the lid of the steel capsule can be screwed fast on this.

The contents of the reservoir are so measured in the clear that a prismatic powder grain can be easily placed in it.

Lid and steel capsule are vaulted, in order to accelerate the exhaustion of the air by pumping.

In the steel capsule in the upper part and in the lid in the lower part, there is an air-tight cock. The reservoir communicates with these cocks by means of two channels, which, for fine-grained powder, are shut off by a steel tinplate filter, the holes of which have a width of 0·3 mm. The two tubes, 1 and 2, are screwed air-tight on the plugs of the two cocks 1 and 2. At the upper ends of both tubes funnels of glass are squeezed in for more conveniently filling and emptying the mercury. The shorter tube, No. 1, of about 600 mm. length, carries in the centre a glass-tube, about 200 mm. long, divided into millims, and can, just above this tube, be closed air-tight by means of a screw cramp. The interior diameter of the tube No. 1 is about 9 mm., whilst that of tube No. 2, which is about 2,500 mm. long, measures only about 5 mm. The gutta-percha tubes are spun over on the outside.

Reservoir and tube 1 are fastened in a wooden frame; funnel 2 is in a wooden lining.

This precaution has been taken for the reason that the temperature of the mercury and of the apparatus should be altered as little as possible during the operation by the warmth of the hands. By means of two strings, which run over rollers fastened in the ceiling of the room, funnel 1 and funnel 2 can be pulled up or down at pleasure.

The auxiliary apparatus further required :

1. A thermometer, by means of which, previous to, during, and after the filling in of the mercury, the temperature of the same will be ascertained.
2. A fine pair of scales indicating to 0·001 grammes, with a carrying capacity of 6 kilos. (each scale 3 kilos.)
3. A barometer for determining the pressure of the atmosphere at the place of operation.
4. A wooden scale, 1 m. long, with a steel point, and a slide for exactly measuring the difference in the levels of the mercury meniscus in the two tubes 1 and 2.

Theory of the Densimeter.

Let the weight of the reservoir, with the tubes screwed off, but inclusive of the connecting piece screwing the capsule and the lid together, = R grammes. After the reservoir has been exhausted, and filled with mercury, let its weight at temperature t° of the chemically pure mercury = T grammes.

Consequently the contents of the reservoir filled bythe mercury amount to—

$$I = \frac{T - R}{13{\cdot}59(1 - 0{\cdot}00018\, t^\circ)} \text{ cub. centim.}$$

If now P grammes of powder be placed in the reservoir, and the air exhausted and the remaining space filled with mercury, the whole will weigh, at temperature t°, only T′ grammes, hence if Y is the volume of the P grammes powder, at t° temperature,

$$V = \frac{T - T' + P}{13{\cdot}59\,(1 - 0{\cdot}00018\, t^\circ)}\ ,$$

consequently the specific gravity of the powder to be examined

$$\frac{P}{V} = \text{specific gravity} = P\,\frac{13{\cdot}59\,(1 - 0{\cdot}00018\, t^\circ)}{T - T' + P}.$$

The following examples will serve as illustration :

The specific gravity of chemically pure mercury amounts at

0° Cels. = 13·59 ; 10° Cels. = 13·57 19° Cels. = 13·55 ; 27° Cels. = 13·53
5° Cels. = 13·58 ; 15° Cels. = 13·56 23° Cels. = 13·54.

Example 1.

T = the reservoir filled with mercury weighs at 19° Cels. = 1091·6
R = the empty reservoir - - - - - = 329·6

Q = T − R. Consequently mercury 762·0 grammes.

Consequently contents of the reservoir at 19° Cels.

$$I=\frac{T-R}{13{\cdot}59\,(1-t\,0{\cdot}0018)}=\frac{762{\cdot}0}{13{\cdot}55}=56{\cdot}236 \text{ cub. centim.}$$

If now 60 grammes (= P) gunpowder is placed in the reservoir, and the remaining space filled with mercury, we obtain

611·6 grammes $(=T_1)$
Reservoir empty = 329·6
60 grammes powder = 60·0
R + P = 389·6 deducted,

remains Q = 222.0 grammes weight of the mercury filling the intervening space, occupying at 19° Cels.

$$I=\frac{222{\cdot}0}{13{\cdot}55}=16{\cdot}444 \text{ cub. centim.}$$

Consequently volume of the 60 grammes powder = 56·236 − 16·444
V = 39·792 cub. centims.

$S=\frac{P}{V}$ = specific weight of the 60 grammes gunpowder

$$\frac{60}{39{\cdot}792}=1{\cdot}507$$

Example 2.

If a powder prism weighs 42·0 grammes at 190° C. and weight of reservoir, powder prism and mercury = 808·4 grammes.

Reservoir empty 329·6
42 grammes powder 42·0
371·6

consequently of 808·4
371·6 deducted,
= 436·8 grammes weight of mercury,

or $\frac{436{\cdot}8}{13{\cdot}55}=32{\cdot}236$ cub. centim. occupied by these 436·8 grammes.

Consequently volume of the 42 grammes weighing powder prism = 56·236 − 32·236 = 24·0 cub. centim.

Thus, specific weight of the powder prism $=\frac{42{\cdot}0}{24{\cdot}0}=1{\cdot}75$

General Formula.

$$S=\frac{P}{V}=\frac{P}{I-I^1}=\frac{P}{\frac{T-R}{13{\cdot}59(1-t\,0{\cdot}0018)}-I^1} \text{ or } I^1=\frac{Q}{13{\cdot}59\,(1-t^\circ\,0{\cdot}0018)},$$

$$S=\frac{P\,[13{\cdot}59\,(1-t\,0{\cdot}0018)]}{T-R-Q^1}. \qquad \text{Since } Q^1=T'-R-P$$

$$S=\frac{P\,13{\cdot}59\,(1-t\,0{\cdot}0018)}{T-T'+P}$$

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The extension of the examples 1 and 2, therefore, is essentially facilitated :

Example 1.

Given $P=60$ gr. $t=19°$ C., consequently $13·59\ (1-19-0·0018)=13·55$

$T=1091·6$ grammes, $T'=611·6$ grammes.

$$\text{Thus } S=\frac{60·13{,}55}{540}=1·507$$

Example 2.

Given $P=42$ grammes $t=190°$ C.,

consequently specific weight of mercury $=13·55$.

$T=1091·6$ $T'=808·4$

$$\text{Thus } S=\frac{42·13{,}55}{325·2}=1·75$$

Because the expansion coefficient of the reservoir made of steel is different for changing temperatures from that of the mercury, it will be necessary for determining once for all empirically the weights of Tn for ± 0, $+5$, 10, 15, 20, 25, 30, 35° Cels., to calculate the required cubical contents of the reservoir $=$ Vn, to interpolate them graphically, and to embody them from degree to degree in a table.

DIRECTIONS FOR USE OF THE DENSIMETER.

The temperature of the mercury is determined and noted before, after, and during the period of operation. For that purpose it is advisable to employ a thermometer composed of a very fine glass tube, which admits of being inserted in the gutta-percha tube No. 1, which has been filled up to the aperture of the funnel.

The mercury in funnel 1 will show, on account of the friction and consequent heating, $1-3°$ more heat than that in funnel 2. This difference is, however, equalised in a very short time.

During the operation the apparatus must only be touched on the wooden lining, in order to avoid as much as possible any variations in the temperature which may be caused by the warmth of the hands. The powder to be tested must be of nearly the same temperature as the mercury to be employed, for which purpose it will be best to keep both before the testing operation for several hours in the same room. The reading of the barometer which indicates the pressure of the atmospheric air must be noted down.

1.

The two tubes 1 and 2 are screwed air-tight to the reservoir, the two cocks are opened, and the apparatus fastened in the wooden frame with vertical position of the tube No. 1.

Thereupon the funnel T'' is lifted to the level of T' (upon $+760$ mm.), and chemically pure mercury poured into the funnel T'', until both funnels are filled with mercury to a height of about 20 mm. The mercury will then stand 760 mm. high above the (± 0) point of the reservoir ; consequently the pressure upon the highest point of the reservoir will be altogether two atmospheres (1 atmosph. pressure corresponding in the mean to 760 mm. mercury.

Under this pressure the air in the reservoir will for the greatest part be already forced up, and in fact in the direction towards funnel 1.

2.

Now the cramp screw-piece is attached below the funnel 1, and above the glass tube in the centre of the hose 1 filled with mercury, and the latter shut off air-tight at a height of about +600 mm. Then funnel 2 is sunk to about 1,000 mm. below the zero point of the reservoir. The mercury level will thereupon sink below the reservoir. In case reservoir and hose 1 were already exhausted of air, the difference of the level of both the mercury menisci will be exactly as much as indicated by the barometer, otherwise the difference will be smaller. All the mercury then flows back from the reservoir, &c. into the funnel 2, for which reason the same must have a sufficiently large capacity, and must be lowered carefully, not too quickly. Cock No. 1 is then shut, funnel No. 2 lifted above the zero point of the reservoir, and the latter, which in the most unfavourable case will contain only extremely rarified air, filled by the same; then cock 1 is opened, and the cramp at the hose No. 1, so that the mercury in the funnel No. 1 can rise again. This exhausting of the air is repeated a second time if necessary.

For testing whether the reservoir is entirely or sufficiently exhausted of air, funnel 2 is sunk so far until its mercury level has reached about 400 mm. below the zero point of the reservoir. Now occurs a Toricelli's vacuum in hose 1, and the mercury meniscus is seen in the glass tube.

If there were still air in hose 1, the level-difference in the hoses 1 and 2 will be smaller than the height indicated by the barometer for the day in millimeters. In this case the operation mentioned before is repeated. In all cases at a position of funnel 2 at about −440 mm., the difference of the level of both the mercury menisci will be, at the utmost, smaller by 2–3 mm. than the indication of the barometer for the day. If the difference in the variation of the levels should show itself equal to the height of the barometer, which may be easily ascertained by the scale, by adjusting the slider fastened at the height indicated by barometer at the upper meniscus in the glass tube; the pressure at the upper part of the reservoir will then be—

$$\left.\begin{array}{l}\text{1 atmosph. air pressure}\\ -\text{ 1 atmosph. mercury pressure}\end{array}\right\} = 0 \text{ mm.}$$

consequently the reservoir is exhausted of air.

But in order to employ a further powerfully-acting means for exhausting the air, so far as this should not have been accomplished already, the funnel 2 is lifted as high as possible up to about 2½, 760 = 1,900 mm., thereby the very small quantity of air still present will be forced into the hose 1 under $2\frac{1}{2} + 1 = 3\frac{1}{2}$ atmospheric pressure, and will ascend either towards the hose 1, or occupy only a small and practically insignificant place, of 0·001 to 0·0001 cub. cent. by shutting off the cocks 1 and 2.

The raising and lowering of hose 1 and 2 is performed by pulling or slackening the cords running over the rollers fastened into the ceiling of the room.

It may now be supposed that the air is completely exhausted from the reservoir, and that its vacuum is completely filled with mercury. At all events the hydrostatic air pump of 0 to 3·5 atmosph. pressure, attached to the apparatus in the simplest manner possible, will act much more powerfully than any other air pump.

Finally, the two cocks 1 and 2 in the mercury are shut off, the temperature of the latter being determined, the two hoses 1 and 2, which have previously been carefully emptied, are unscrewed, the reservoir cleaned of the mercury globules sticking to it (especially in the parts of the screw and the interior channel-openings of the cocks), and the weight of the reservoir, including bolt, determined with mercury.

DETERMINATION OF THE SPECIFIC WEIGHT OF THE POWDER TO BE TESTED.

The prisms or pieces of cake, or the coarse or fine-grained powder to be tested, are accurately weighed on a scale.

The powder prisms of 25 mm. height, 40 mm. measured across the edges, 35 mm. on two sides, with channels each of 4·2—4 f mm. wide, or one channel 10 mm. wide, weigh, as a rule, at a specific weight of 1·6 to 1·8, from 36 to 44 grammes.

Of grained powder so much is weighed that the steel lid can be easily fixed on the reservoir, and fastened with the bolt, consequently about 50 grammes in case of a small reservoir with about 76 cub. cent. capacity, or 200 gr. in case of a larger reservoir of about 217—226 cub. cent. capacity. The quantity of powder weighed is filled into the reservoir; this is then closed, the two hoses 1 and 2 are screwed on, and the operation is thereupon proceeded with as detailed in the preceding explanations.

It must be observed that the operation is very simple and expeditious, excluding every personal error, so that, consequently, the method, being based on scientific principles, is a thoroughly rational one.

It should cause no surprise if the operations 1 and 2 must be repeated several times, when the powder has been filled in, in order to raise the difference of the level of the two mercury columns to the same height as the position of the barometer, as the large capacities of the coal of the powder for absorbing air is a notorious fact, and as also the moisture contained in the powder is to a very great extent evaporated in the form of aqueous vapour, or ejected by hydrostatic pressure and tension.

373. Mercurial Powder Balance, Major Bode's construction, for determining the specific gravity of prismatic and coarse-grained gunpowders. *A. and R. Hahn, Cassel.*

The mercurial powder scale replaces the alcohol or so-called "volumetrical analysis method," and by means of this instrument the specific weight of the different sorts of powder, prismatic, powder-cake, and coarse-grained can be exactly determined with quantities of 40 to 50 grammes.

380. Balance for Weighing in Vacuo.

Paul Bunge, Hamburg.

The vacuum scale is a duplicate of a similar scale made by the exhibitor for the Physiological Institute at Kiel. For facilitating exhaustion it has been enclosed in a small receiver of 5 inches diameter and 10 inches in height, which was only possible by the exhibitor's system of employing a short beam. This is 69 millimeters long, and with a load of 50 gr. the balance turns with $\frac{1}{20}$ mgr.

The use of the scales is as follows:—After the body which is to be weighed in dried air or in a vacuum has been placed on the scales, and the exhaustion or the desiccation has been effected, the scale can be arrested and released by turning three studs fixed in the bottom plate. All weights of 20 gr. to 0·01 gr. can be placed on or lifted off the pan. Lastly, a rider can be traversed the whole length of a beam in the line of the axis.

VI.—MEASUREMENT OF VELOCITY.

A. LOGS AND CURRENT METERS.

393. Patent Log, by Massey. For measuring speed at sea; in use in H.M. Navy.
Hydrographic Department of the Admiralty.

394. Patent Log, by Walker. For measuring speed at sea.
Hydrographic Department of the Admiralty.

394a. New Ship's Log. *Benjamin Theophilus Moore.*

In this log a revolving cylinder, furnished with screw blades, is placed behind a tube, the front portion of which terminates in a solid pointed head. The cylinder turns upon a spindle, in bearings inside the tube. Within the revolving cylinder is a water-tight tube of glass containing the recording mechanism. This tube is drawn out for the purpose of reading the dials.

The log line is attached near the centre of gravity of the whole instrument, by which means the log is made to run horizontally, and *below* the surface of the water, and as steadily as an arrow in the air.

The mechanism, being entirely protected from contact with sea water, works smoothly, and cannot get out of order.

The glass tube is itself protected from any injury by the manner in which it is contained within the revolving cylinder.

This log will indicate any distance, from one-tenth of a cable to one thousand miles, with great accuracy.

394b. Massey's Patent Ship's Log. *E. Massey.*

Massey's Patent Frictionless Sounding Log.
E. Massey.

394c. Massey's Frictionless Propeller Conical End Log. *E. Massey.*

394d. Massey's Patent Self-registering Ship's Logs.
L. P. Casella.

These logs are constructed on the rotating system devised by E. Massey, and have registers and mile indices, to show distance run during the time the log is overboard towing astern of ship.

394e. Reynold's Patent Pendent Log.
J. Cohen & Co.

This log is composed of two parts; first, the rotating log itself, and second, the apparatus for registering the distance run while the log is overboard.

398. Ramsten's Patent Ship's Log. *Elliott Brothers.*

396. Current Meter, for measuring the velocity of currents in rivers at different depths. *Elliott Brothers.*

An endless screw on a spindle turns two wheels at the same time, the one recording every revolution of the blades by moving one division; the other indicating every complete revolution of the former.

397. Revy's Current Meter, constructed for measuring the velocity of currents in larger rivers. *Elliott Brothers.*

The spherical boss is so determined that it will displace just as much water as will balance the weight of all the parts which are fixed to the spindle, so as to reduce friction to a minimum. Although the apparatus is covered with glass, it has to be filled, before using it, with pure water to establish similarity of pressure inside and outside. After every experiment the water is removed and the spindle thoroughly dried. This form of current meter was used by Mr. Revy in the survey of the Parana and Uruguay rivers.

397a. Darcy-Pitot Gauge or Current Meter, for determining the velocity of streams of water. *Prof. W. C. Unwin.*

The velocity is obtained by a single measurement, and no time observation is required. Used in Darcy and Bazin's researches on the flow of water in pipes and canals.

399. Water Meter, based on the principle of measuring the volume of water by recording its speed. *J. A. Muller, C.E.*

This water meter consists principally of an air and water-tight chamber or vessel, wherein moves a float, carrying two magnets of equal power, and fixed with their dissimilar poles in juxtaposition to each other: the whole combination of the float and its spindle, together with the magnets, is made as near as possible equal in density or specific gravity to the water. The water in passing through this measuring vessel is forced to take a rotary motion, by means of a screen or a tongue, being a metal piece, put at a certain distance from the inlet opening, and parallel with and lying along the inner circumference of the measuring vessel. The top cover of the measuring vessel is properly dished out, so as to allow of two small soft iron armatures, fixed to a thin metal arm or needle, to be brought outside the vessel, as near as can be to the poles of the magnets inside; the metal arm or needle is fixed to a light spindle, carrying an archimedean screw, which further gears with the registering parts of the apparatus. It is evident that the water in passing through the measuring vessel, or rather alongside the same, communicates its motion to the water inside the measuring vessel, which motion is also communicated to the float and magnets, and lastly to the needle and worm spindle and further gearing. It is plain that this meter really registers the true velocity of the water, and taking, moreover, into consideration the lightness of its different parts and the transmission of the speed of the float by means of magnets, it will be found to be a very correct and sensitive meter, of simple and durable construction.

399a. Current Meter, with electrical tell-tale apparatus, according to Amsler's latest construction. (*See* description.)
Polytechnic School, Aix-la-Chapelle, O. Intze.

If the instrument makes 100 revolutions the electric current will be closed by a contact, and the chime work will be kept in motion during some revolutions of the instrument; it will not be necessary, therefore, in measuring the velocity in water-courses, to pull the instrument out of the water, but only to note the time which passes from one signal to the other. By experiments it must be ascertained what velocities of the current of the water correspond to certain intervals of time between the electric signals.

400. Patent Electric Velocimeter, invented by Francis Pastorelli, arranged for water currents, and for ascertaining the speed of vessels. It consists of three parts. *Francis Pastorelli.*

1. Four hemispherical cups are fixed to the end of four strong metal arms that radiate at right angles from a central boss, mounted on a horizontal axis at right angles to a framework of metal, or other material, so that they may freely revolve when placed in the water. The horizontal axis has fixed to it a point or piece of platina; upon this work pressing points or surfaces, which can be made of any form, circular or otherwise; each revolution of the axis causes a contact to be made.

2. The same receiving instrument, as used for the mining instrument, No. 3388.

3. A Leclanché battery, as used for the mining instrument.

The receiving instrument can be placed in any convenient position on board.

N.B.—No. 1. This part of the instrument is intended to be fixed at any desirable and convenient part of the vessel, or it may be arranged to throw overboard; under such conditions it will give more accurate indications than the logs now in use, for it is not affected like them in their motion by depth, or the increasing density of water; assuming that corrections be applied for force and direction of currents, with respect to the course or line of motion, the errors would probably not be found to exceed 5 per cent.

402. Apparatus for indicating the **Speed** of a **Ship** by the aid of **Electricity.** *Bennet Woodcroft, F.R.S.*

409. Rhysimeter, without frictional parts, for measuring the speed of water or other liquids whether in pipes or open channels. *Alfred E. Fletcher, Liverpool.*

409a. Current Meter.

Benjamin Theophilus Moore, M.A.

This instrument will measure the velocity of running water at any depth below the surface, with accuracy and facility.

The frame is formed of thin brass bars united in front to a solid ogival head, and terminating, in the opposite direction, in a double vane or tail. It is suspended in water by a cord attached to a stirrup.

The frame supports a hollow cylinder which is provided with six screw blades, and is free to revolve upon fine pivots at its extremities. This cylinder contains a water-tight glass tube within which is a simple train of mechanism to record the number of revolutions made by the cylinder. This train of mechanism is suspended in such a manner, that it remains at rest while the cylinder revolves, and the dials which record the number of revolutions are seen through the glass without opening the cylinder. When the instrument is suspended in running water by a cord attached to the stirrup, the frame immediately takes up a position in which the axis of the revolving cylinder is parallel to the direction of the stream. The cylinder is set in motion, and stopped, at known instants, while under water, by means of a spring operated upon by a light cord.

For use in very deep water a simple automatic starting and stopping apparatus is placed inside the water-tight compartment of the cylinder, which operates in such a way that while the instrument is descending or ascending in water, the mechanism does not record the revolutions of the cylinder, but only while it is at the depth at which the velocity is required. In this case the spring is removed and one cord only is used.

409b. Deep Sea Current Indicator.

Benjamin Theophilus Moore, M.A.

This instrument is intended to be used for the purpose of ascertaining the direction of submarine currents.

It consists mainly of a water-tight globular shell of gun metal, pointed in one direction, and terminating in the other in a long double vane, and is carried by two pivots on a stirrup. Within the shell is a brass box, suspended by gimballs in the manner of a ship's chronometer, and containing a magnet with a graduated ring, and a train of clockwork. When the instrument is lowered into deep water, its principal axis takes the direction of the current, while the magnet settles itself in the magnetic meridian. After the magnet and the instrument have taken up their respective positions, the clockwork suddenly fixes the magnet at a known time. The instrument is then drawn up out of the water and opened, when the fixed magnet shows the direction, or bearing, of the current below.

This bearing is shown directly by the instrument when it is suspended from a fixed platform, or from a ship at anchor, or otherwise at rest: When the ship is in motion the instrument is to be used in combination with the deep sea current meter, by which means the velocity and direction of the submarine current can be determined simultaneously by a simple geometrical construction.

409c. Recorder for Indicating Speed, Pressure, &c.
W. H. Bailey and Co.

B. ANEMOMETERS.

408. Anemometer, without frictional parts, suited to measure the speed of air or gases, even when highly heated, or when contaminated with smoke or corrosive vapours. Used by H.M. Inspectors of Alkali Works. *Alfred E. Fletcher, Liverpool.*

410. Lowne's Portable Air Meter, originally introduced by Casella. *R. M. Lowne.*

The indications of this instrument are obtained by means of a light fan which communicates motion to indicating wheels; the dial of the instrument is placed at right angles to the fan, and is supported by three pillars on a base, which also carries the tube containing the fan. The works are extremely sensitive, the first centres running in jewels, and the indicating parts can be thrown in or out of gear with the fan.

410a. Lowne's Patent Magnetic Air Meter, especially adapted for measuring currents of air, gases, and fluids in positions where delicate instruments would be subject to corrosion.
R. M. Lowne.

The peculiarity of this instrument is, that the registering works are enclosed in an air-tight chamber, the connexion of the revolving fans with the works being made through a sheet of brass by magnetism. The fans carry a small bar magnet, and the first wheel of the indicating mechanism carries a piece of soft iron, so that when the fans revolve outside the plate of brass the soft iron revolves within by attraction and thereby moves the works.

410b. Lowne's Patent Colliery Air Meter, constructed expressly for use in mines. *R. M. Lowne.*

The external aspect and form of this instrument is that of the well known "Biram's Anemometer." The improvements consist of.—1st, a strong, light, and anti-corrosive fan; 2nd, a large clear dial; 3rd, the indicating parts are perfectly protected from dust and smoke; and 4th, a lever is placed in a convenient position to enable the observer to throw the indicating wheels in or out of gear with the fan.

410c. Lowne's Patent Magnetic Anemometer and Current Meter, for measurement of velocity of currents of air, gas, and fluids. *R. M. Lowne.*

In this instrument the registering works are enclosed in an air-tight chamber, the connexion of the revolving fans with the works being made through a sheet of brass by magnetism. This instrument is mounted on gymbals, with direction vane for use on board ship.

410d. Lowne's Patent Ventilation Anemometer, originally introduced by Stanley. *R. M. Lowne.*

This instrument measures the air by means of a fan wheel placed in a clear opening, without any obstruction from the registering apparatus, which is in a separate chamber on the same plane as the fans, so that the instrument is quite flat for the pocket; the whole of the works are of extreme sensitiveness, and the axes of the fans run in jewels, the indicating hands give the current that passes the fans in feet (after correction), and a lever above the dial throws the registering works in or out of gear with the fans.

410e. Mining Anemometer, for showing the velocity of currents in mines. *Elliott Brothers.*

410f. Biram's Anemometer. Improved for Coal Mines. *Francis Pastorelli.*

It consists of a broad brass ring; fixed to it is a metal frame which carries three divided circles; in the interior and centre of the ring is a spindle which carries eight vanes; on one end is an endless screw; this works a series of wheels, which give motion to the hands on the dials, which record the distance travelled by the air current every foot up to 100, 1,000, and 10,000 feet.

410g. Dickinson's Anemometer. *Joseph Casartelli, Manchester.*

This anemometer consists of a disc, or plate, made of light material, suspended in a frame on delicate centres, having a balance weight attached to the top of the fan. To one side of the frame is fixed on pivots a quadrant opening out at right angles to the fan, and on it is marked the velocity of the current in feet per minute, as indicated by the angular rise of the fan upon which the current impinges. The advantage of the instrument consists in the fact that *it requires no timing* as required by every other instrument, and from actual experiment it is found as accurate as the most delicate instrument.

410h. Improved Biram's Anemometer. *Joseph Casartelli.*

The improvement in this instrument consists in the fan being made of light material, thus greatly diminishing the friction, and rendering it a delicate and useful instrument.

410i. Biram's Patent Anemometer for ascertaining the current of air in mines, air flues, &c. *John Davis and Son.*

This anemometer registers up to 1,000 feet. At the bottom there is a tube in which a stick may be inserted, so that the experimenter can stand at a distance from the instrument, otherwise the current of air would be deflected by the body of the experimenter.

The vanes may at will be disconnected from the indices by means of a stud at the side, thus rendering the process of timing more simple and exact.

410k. Biram's Patent Anemometer for ascertaining the current of air in mines, air flues, &c. *John Davis and Son.*

The 4″ anemometer indicates up to 10 million feet. The size and angle of the vanes are calculated from theory and corrected by experiment, each instrument being corrected separately.

The registering apparatus consists in the 4 in. new anemometer of six small circles, marked respectively X, C, M, X M, C M, and M, the divisions on which denote units of the denominations of the respective circles; in other words, the X index in one revolution passes over its ten divisions and registers 10 × 10 or 100 ft.; the C index in the same way 1,000 ft.; and so on up to 10,000,000 ft.; so that an observer has only to record the position of the several indices at the first observation (by writing the lowest of the two figures on the respective circles between which the index points in their proper order), and deduct the amount from their position at their second observation, to ascertain the velocity of the air which has passed during the interval; this multiplied by the area in feet of the passage where the instrument is placed, will show the number of cubic feet which has passed during the same period.

The novelty in this anemometer is in its extreme portability and substantial workmanship; it is supplied with a lever which disconnects, at will, the vanes from the indices, thus rendering the process of timing more simple.

414. Edelmann's Anemometer with galvanic register. *M. Th. Edelmann, Munich.*

416. Anemometer for determining the velocity of the air, and other gaseous currents in pipes and air passages. *Moritz Gerstenhöfer, Freiberg.*

C. CHRONOGRAPHS.

401. Apparatus for measuring the velocity of projectiles, and capable of recording several measurements on one and the same trajectory and of the same projectile. *Antoine Joseph Gérard, Liége.*

403. Ballistic Chronoscope, with two pendulums, for ascertaining the speed of a projectile at any point of its trajectory, by measuring the time of flight of a portion of the trajectory; also for measuring portions of time between one tenth of a second and 25 seconds. *Lieutenant-General Leurs, Brussels.*

404. Electric Chronograph, for measuring the initial velocity of projectiles. *Le Boulengé, Liége.*

405. Electric Clepsydra, for measuring the time of flight of projectiles. *Le Boulengé, Liége.*

405a. Electro-Ballistic Apparatus, for determining the velocity of a projectile, with description of experiments and additional apparatus. *M. Navez, Paris.*

406. Electric Chronograph for the measurement of minute portions of time, &c., &c. *Lieut. H. Watkin, R.A.*

This instrument consists of two upright cylinders resting on a base of wood; between them, suspended by an electro-magnet, is a weight with projecting arms. The cylinders being connected with the secondary circuit of an induction coil, the circuit is complete with the exception of the small spaces on either side of the weight. When taking velocities of shot, the primary circuit is led through screens, constructed so that the current is broken and immediately made again during the passage of the shot. The gun being fired, the weight begins to descend; the shot in passing the first screen causes a spark to flash from one cylinder to the other through the weight which having been previously smoked registers by a white spot the position of the weight at that instant. As the weight continues to descend the same result is obtained at the next screen, and so on. Adjacent to the cylinder is a time scale divided into thousandths of a second, subdivided by a vernier of novel construction into hundred thousandths of a second, by which the absolute time taken by the shot between the screens is easily read off. For other uses to which the instrument may be applied, see Royal Artillery Institution Papers.

407. Clock-Chronograph, contrived for the purpose of measuring the time occupied by projectiles in passing over a succession of equal spaces, with a view to determine accurately the resistance of the air to their motion. *Rev. F. Bashforth.*

If the fly-wheel be spun by hand, and the markers be brought down, they will trace two uniform spirals on the cylinder; each marker is, however, under the control of an electro-magnet. When the galvanic current is interrupted, a record is made by the corresponding marker being suddenly drawn aside. The circuit of the lower electro-magnet is interrupted once a second by a clock beating half-seconds, which gives a scale of time. The circuit of the upper electro-magnet passes along the tops of all the screens, as is shown in the case of one screen. When one or more threads are broken in any screen, a record is made on the cylinder. Thus, when an experiment is to be made, the fly-wheel is spun briskly by hand, the markers are brought down, and the gun is fired. The times of passing the screens are recorded on one spiral, opposite a scale of time on the other. This instrument was used in making all the experiments referred to in "Reports on "Experiments made with the Bashforth Chronograph to determine the "Resistance of the Air to the Motion of Projectiles, 1865–1870," published by authority. Generally 10 screens were placed at intervals of 150 feet, but in the experiments with the Whitworth gun (p. 162), 16 screens were placed at intervals of 75 feet; some of these records are shown. For a full description of the chronograph, see Proceedings of the Royal Artillery Institution, Woolwich, for 1866, which description is also published separately.

407a. Chronograph for projectile experiments with the recording apparatus of Deprez. *Dumoulin Froment, Paris.*

407b. Electric Chronograph. *Dr. Werner Siemens.*

This instrument, which was described in the year 1845 in Pogg. Ann. (Bd. 66, p. 435), serves for the measurement of high velocities, especially those of projectiles both along the barrel and in their further flight, and also that of electricity.

It is based on the circumstance that an electric spark leaves a sharp mark on polished steel, and that this mark can easily be discovered when the cylinder has been previously blackened. The cylinder is turned rapidly by clockwork, and each hundredth revolution is marked by the stroke of a small bell. By means of a regulator the rapidity of rotation is so arranged that the stroke of the bell coincides exactly with the beat of a second pendulum; the reading is made with a microscope with cross wires, the clockwork being stopped. The graduation of the micrometer head gives 0·0001 of a revolution of the cylinder or millionths of a second if the cylinder rotates 100 times a second.

The measurement of the velocity of projectiles is effected by the passage of an electric spark at the moment when the projectile touches an insulated wire which reaches to the inside of the gun, and thus is free from retardation caused by the inertia of matter or magnetism.

The same apparatus can be used for the measurement of the velocity of electricity in suspended wires.

The complete apparatus comprises a Leyden jar, induction coil, commutator, gun barrel, chronograph, and two batteries.

407c. Recording Cylinder, with original marks by which the speed of electricity in iron wires has been measured.
Dr. Werner Siemens.

Those marks which are surrounded by a halo or circle indicate the commencement of the discharge, the successive series of small marks has been formed by the electricity which has traversed the conductor; the angular distance between the first-mentioned mark and the first point of the series gives the measurement of the speed of electricity. By measurement of the time which the electricity requires to pass through lines of various lengths, the electrostatic retardation, which is proportional to the square of the length of the line, has been eliminated. By these researches it has been shown that electricity is transmitted in conductors with a constant velocity which is independent of the static retardation, and which for iron amounts to about 230,000 kilometres per second.

(See Monatsberichte der Kgl. Pr. Acad. der Wissenschaften, 6 Dec. 1875.)

411. Complete Apparatus for measuring the Velocity of Projectiles in the bore of a gun, and for measuring the speed of electricity. *Siemens and Halske.*

412. Vibration Chronograph, for measuring the time of descent on an inclined plane, executed according to Beetz, by M. Th. Edelmann, at Munich. (A description accompanies the object.) *Prof. Dr. Beetz, Munich.*

413. Edelmann's Apparatus for the descent of a falling Body accessory to Beetz's chronograph.
M. Th. Edelmann, Munich.

413a. Chrono-Goniometer, with magnifier.
Le Vicomte Duprat, Consul-General of Portugal.

D. STROPHOMETERS.

44. Counters and Speed Indicators.
T. R. Harding and Son.

(*a.*) Counters with reciprocating motion, as applied to marine and stationary engines.

Counters with rotary motion, suitable for shafting, printing, and other machinery.

Small counters with rotary motion applicable to spinning machinery and various other purposes.

Pocket counters for ascertaining the speed per minute of spindles or quick running machinery up to 10,000 revolutions per minute.

(*b.*) Counters actuated by pneumatic and electric apparatus at a distance from the motion to be indicated.

(*c.*) Speed indicators, showing by the height of a column of mercury the actual speed, at any moment, of engines and other machinery.

44a. Mercurial Indicator and Counter.

T. R. Harding and Son.

The above instrument is a combination of Harding's integrating counter and Brown's patent indicator, for which T. R. Harding and Son are sole licensees in Great Britain.

The mercurial indicator shows the speed per minute of the shaft above it; the counter records *half* the number of revolutions of the same shaft.

The principle of the mercurial indicator is very simple. The tubular arms of the rotating U tube are connected with the central glass tube, and when the instrument is at rest the mercury settles to a level in the glass tube and arrives at the zero of the scale. When the instrument is rotated, the mercury, owing to the centrifugal tendency, rises in the arms and sinks in the central tube to a greater or less extent according to the speed.

These indicators are of great importance for marine, stationary, and locomotive engines, as well as for various kinds of machinery.

By means of the counter and a watch, the accuracy of the mercurial indicator can at any time be verified.

47. "The Motometer," a machine to indicate the number of revolutions made per minute, or other portion of time, by a steam engine or revolving shaft, or any body having intermittent motion, so that by simple inspection of a dial the rate of speed may be seen. *H. Faija.*

This instrument is constructed so as to indicate by a positive motion direct from the engine or other moving body to which it is attached, and is of purely mechanical construction independent of all centrifugal and other forces of an indirect nature. The indication is consequently absolute and not comparative.

The instrument is made in various forms to suit differences of speed, from the slow stroke of a pumping engine to the high speed of a locomotive, &c.

The skeleton machine exhibited is suitable to indicate the ordinary speed of a marine or stationary engine, while the one attached to the shafting is adapted for very high speeds.

395. Hearson's Patent Strophometer or Revolution Indicator, an instrument for showing at a glance, by the position of a pointer on a graduated dial, the number of revolutions per minute an engine is at the time making. *Elliott Brothers.*

395a. Working Model of Revolution Indicator, for engines and machinery, by J. Wimshurst. *J. F. Flannery.*

415. Mercurial Gyrometer, or "orbit meter."

Royal Polytechnic Academy (*Prof. Reuleaux, Director*), *Berlin.*

The instrument indicates directly the angular velocity of an axle, shaft, &c., in figures showing the rotations per minute. The reading takes place on an alcohol column, which shows on one side a millimeter scale, and on the other the rotation numbers. The instrument is so arranged that the scale of the rotations has uniform graduation.

532b. Reuleaux's Ball-Gyrometer.

H. Hädicke, Engineer, Demmin, Pomerania.

The object of the instrument is to indicate the rotations made per minute by any rotating body brought into connexion with the same. The number indicated will be read off a dial. As a peculiarity it may be mentioned that the scale of the dial shows a uniform division, although the position of the balancing balls moving the pointing hand depends—according to a complicated law—on the velocity of the rotation of the spindle.

The motion is worked by means of straps and pulley, and can, as a matter of course (on vessels, &c.), be effected by a fixed connexion with a shaft-movement.

The winch-handle, however, will enable the spectator to put the instrument in motion by the hand.

The accuracy of the indications of the instrument will be augmented if the pointing hand is turned off a little with the finger in the direction of the progressive numbers, and then allows it to jerk back freely.

A forcible turning of the pointing hand in the opposite direction, toward O, is not allowed.

415a. Revolution Indicator, to show the rate at which machinery is working. *Frederick Guthrie.*

From the machinery an up-and-down motion is communicated to the piston of a pneumatic forcing pump. The compressed air escapes through a fine opening, and also exercises pressure on oil, water, or mercury, in a vessel provided with a manometer tube. The height of the liquid in the tube measures the rate at which the pump and machinery are working.

488d. Drawings of a Simple Counter, and of a Registering Counter.

(*See* Report of Baron Séguier to the Society of Encouragement, 1844.) *M. Winnerel, Paris.*

VII.—MEASUREMENT OF MOMENTUM.

417. Model of the Ballistic Pendulum, erected in the Royal Arsenal in 1814, and transferred to the Royal Military Repository in 1836. Weight, 7,740 lbs. Centre of gravity below centre of suspension 10·97 ft.; centre of oscillation below centre of suspension 11·88 ft. Scale ⅛th. *Major M. L. Taylor, R.A.*

418. Navez Electro-Ballistic Apparatus. *Major M. L. Taylor, R.A.*

418a. Discussion on Electro-Ballistic Apparatus.

419. Model of Ballistic and Gun Pendulum, as erected at Shoeburyness in 1858. Oscillating system of gun pendulum, weighs 37 lbs. 10·5 oz.; that of the block pendulum weighs 31 lbs. 8·25 oz. Scale, ⅛th. *Major M. L. Taylor, R.A.*

VIII.—MEASUREMENT OF FORCE.

421a. Attraction Meter. An instrument for measuring horizontal attraction. *Dr. Siemens.*

This instrument consists of two horizontal tubes of wrought iron, terminating at each end in a horizontal tube of cast iron. The first-named horizontal tubes are partially closed at their extremities, and communicate with the transverse tubes below their horizontal mid-section. The transverse tubes communicate also by means of a horizontal glass tube of 2 millims. diameter at a superior level to the former.

The whole apparatus being mounted upon three levelling screws is filled to the level of the half diameter of the transverse tubes with mercury, which mercury also fills the whole of the longitudinal connecting tubes; the upper halves of the cast-iron transverse tubes and the glass connecting tube are filled with alcohol, comprising, however, a small bubble of air, which can be made to occupy a central position in the glass tube by raising or lowering the levelling screws.

If a weighty object is approached to either extremity of the connecting tube, an attractive influence will be exercised upon the mercury, tending to a rise of level in the reservoir near at hand, at the expense of the more distant reservoir; and this disturbance of level between the two reservoirs must exercise a corresponding effect upon the index of air in the horizontal glass tube, moving it away from the source of attraction. The amount of this movement must be proportional to the attractive force thus exercised. Variations of temperature have no effect upon this instrument, because the liquids contained on either side of the bubble of air are precisely the same in amount; and the total expansion of the liquids is compensated for by open stand tubes rising up from the centre of the connecting tubes through which the apparatus can be easily filled.

It is suggested that an instrument of this description may be employed usefully for measuring and recording the attractive influences of the sun and moon which give rise to the tides.

The instrument, which is of simple construction and not liable to derangement from any cause, would have to be placed upon a solid foundation with its connecting tube pointing east and west, records being taken either by noting the position of the index upon the graduated scale below, or by means of a self-recording photographic arrangement.

421b. Bathometer. An instrument for measuring the depth of the sea without the use of the sounding line. *Dr. Siemens.*

The total gravitation of the earth, as measured on its normal surface, is composed of the separate attractions of all its parts, and the attractive influence of each equal volume varies directly as its density, and inversely as the square of its distance from the point of measurement.

The density of sea water being about 1·026, and that of the solid constituents composing the crust of the earth about 2·763 (this being the mean density of mountain limestone, granite, basalt, slate, and sandstone), it follows that an intervening depth of sea water must exercise a sensible influence upon total gravitation if measured on the surface of the sea.

The bathometer consists essentially of a vertical column of mercury contained in a steel tube having cup-like extensions at both extremities, so as to increase the terminal area of the mercury. The lower cup is closed by means of a corrugated diaphragm of steel plate, and the weight of the column of mercury is balanced in the centre of the diaphragm by the elastic force derived from carefully tempered spiral steel springs of the same length as the column of mercury.

One of the peculiarities of this mechanical arrangement is, that it is parathermal, the diminishing elastic force of the springs with rise of temperature being compensated by a similar decrease of pressure of the mercury column, which decrease depends upon the proportions given to the areas of the steel tube and its cup-like extensions.

The instrument is suspended a short distance above its centre of gravity in a universal joint, in order to cause it to retain its vertical position, notwithstanding the motion of the vessel, and vertical oscillations of the mercury are almost entirely prevented by a local contraction of the mercury column to a very small orifice. The reading of the instrument is effected by means of a glass tube on the top, which connects the upper surface of the mercury with a liquid of less density. In this is enclosed an air bubble, whose position on a scale indicates the depth of water below the instrument.

Variations of atmospheric pressure have no effect upon the reading of this instrument; but a correction has to be made for variations of atmospheric density as affecting the relative weight of the mercury column, which correction might be avoided, however, by excluding the atmosphere from both the upper and lower surface of the mercury, and connecting the extremities of the column. The only necessary correction is that for the effects of latitude, which may be calculated as depths in fathoms, and tabulated for use with the instrument.

The readings of the instrument have been checked by actual soundings taken by means of Sir William Thomson's steel wire sounding apparatus; and the comparable results agree in all cases as closely as could be expected, considering that the sounding line gives the depth immediately below the vessel, whereas the bathometer gives the mean depth taken over a certain area, depending for extent upon the depth itself.

It is thought that the bathometer may render useful service to the mariner in warning him of changes of depth long before reaching dangerous ground; and the position of a vessel, when no astronomical observations can be taken, may be ascertained by means of the instrument, provided the contour lines of equal depths of oceanic basins were accurately laid down.

421c. Graphical Bathometer, after von Jolly.
University of Munich.

421d. Gravimeter. An instrument for the measurement of the variations of the earth's attractive force, invented by J. A. Broun, F.R.S., and constructed from his drawings by Dr. C. F. Müller, of Stuttgart. *J. Allan Broun, F.R.S.*

The instrument consists of a weight suspended by two gold wires; a single wire fixed to the top of the weight and passing through its centre carries a cylindrical lever; when the lever is turned through 360° at the normal (say southern) station, the torsion of the single wire thus produced carries the weight round through an angle of 90°. The forces then in equilibrium are, the torsion force of the single wire and the attraction of the earth on the weight, which, as the two wires are no longer vertical, has been slightly raised and seeks to attain its lowest point.

On proceeding from a southern to a more northerly station the earth's attraction increases; the amount of this increase may be measured in two ways:—

1st. The lever will require to be turned through *more* than 360° in order to carry the weight to the height due to turning it through 90°. (Had the station been more southerly the lever would be turned through *less* than 360°.) The difference of the angle from 360° measures the increase (or diminution) of weight.

2nd. By removing a small portion of the weight, equal to that due to the increased attraction of the earth, the weight can be turned through exactly

90° by rotating the lever through 360°, as at the normal station. (On proceeding south weight has to be added.)

The following are the instrumental arrangements in order to make these observations :—

The weight has on each of three sides, at its base, a vertical mirror silvered, not quicksilvered) ; the middle mirror makes an angle of exactly 90° with the other two. The lever also carries a vertical mirror, which when there is no torsion in the suspension wire is immediately below and in the same vertical plane with the middle mirror of the weight. A telescope, having a glass scale at the focus of the eye-piece, is adjusted so that images of the scale can be seen (one higher than the other) reflected from the middle mirror of the weight and the lever mirror. When both of these mirrors are exactly in the same plane, the middle division on the scale seen directly with the eye-piece, coincides with the same division in the two reflected images.

By a wheel and pinion (with endless screw and clamp for delicate movement) placed below the instrument, a polished agate point can be made to act on a similar agate point fixed to the lever, so as to turn the latter through any angle. When turned through 360° the middle scale division again agrees with the image from the lever mirror. If the image reflected from one of the side mirrors of the weight does not agree also, the lever is turned through a greater (or lesser) angle than 360°, till this agreement is obtained; the difference of the angle through which the lever has been turned from 360° is obtained from the scale reading, as seen on the lever mirror.

The following apparatus is employed for very small increases or diminutions of the weight. Suspended to and vertically below the lever is a carefully *calibrated* glass wire (1 millimetre diameter), which enters a glass tube fixed below the instrument. At the lower end of this tube is a cistern containing a liquid (distilled water, or as at present, chemically pure glycerine). This liquid can be forced into the glass tube by a screw and piston (as in some barometer cisterns). The liquid is then raised till such a diminution of weight is produced by the immersion of the glass wire as to bring the mirror of the weight through exactly 90°, when the lever is turned through 360°. The length of glass wire immersed is read, by a micrometer microscope and scale, to a thousandth of a millimeter.

Though finely polished agate points have been employed for turning the lever so as to diminish the friction, there is an additional apparatus to ensure that vertical friction has no effect on the observation at last. The lever contains a magnet ; and two bar magnets, with rack-work adjustments for height, are placed one on each side of the instrument, so that by a pinion and rack movement they can be approached to the lever magnet till their force is exactly equal to the torsion force of the single wire, and the agate points are no longer in contact.

The instrument is made to serve for latitudes differing about 10° or 15°, but an auxiliary apparatus carries five platinum rings, which can be lowered upon the weight, so as to make the instrument serve from the equator to the poles, and to any height in the atmosphere.

There are special appliances for portability, by one of which the weight is fixed ; another fixes the lever ; so that strain is removed from the suspension wires, and the suspended parts cannot be shaken from their places. Levels, a thermometer, and other details fit the instrument for the most accurate observations. The suspension wires are fixed at their ends in a special manner, so that the fixed points cannot vary. All the suspended apparatus is electro-gilt.

421d. Photograph of Automatic Bathometer.

A. Gérard, Liège.

In this instrument a lever of the second order supports a glass cylinder containing 100 grammes of mercury by means of a spiral spring attached to its extremity. The variation of the weight of the mercury, due to a change in the altitude of the point of observation, produces a corresponding variation in the length of the spring; this is rendered apparent by means of a pointer 30 centimeters in length, worked by a watch chain passing round a pulley on the axis of the pointer and attached to the lever.

421e. Photograph of Pendulum of Altitude.

A. Gérard, Liège.

The pendulum consists of a glass rod mounted on knife edges; the bob is a cylinder of mercury attached to the glass rod by a spiral spring, thus affording a perceptible variation in time of oscillation, due to variations of gravity.

425a. Drawing of a Registering Statical Gauge for Pressure in Guns. System of W. Paschkiéwitsh.

Captain W. Paschkiéwitsh, St. Petersburg.

2828. Dynamic Anemometer for obtaining the horizontal and vertical pressure of air in motion, upon inclined surfaces of different forms and angles. Manufactured by John Browning.

The Council of the Aeronautical Society of Great Britain.

This instrument is intended simultaneously to determine the component parts—*i.e.*, how much pressure is due to the horizontal, and how much to the vertical—of a current of air when directed against planes of different areas, and of different forms, at angles varying from 15° to 90°. The experiments are tabulated in the Aeronautical Society's Report for the year 1871 (Hamilton and Co.).

426a. Machine for **measuring** the **slipping** between **hard surfaces** rolling in contact. *Prof. Osborne Reynolds.*

This machine was constructed for the purpose of verifying the conclusions of the exhibitor respecting rolling friction, and the existence of a certain amount of slipping between two smooth surfaces of different curvature, or different hardness, when the one rolls on the other under pressure. It has also been used to measure the slipping between the surfaces, when the one is driving the other against various resistances and at various speeds, as well as the wear of the surfaces.

The large rolling surface is of cast-iron, supported so that it can rotate freely, but otherwise rigidly fixed. For the smaller surface various materials have been used, that exhibited being of steel; this cylinder is supported so that while its axis is always parallel to that of the larger cylinder, it can be pressed against the latter with various degrees of pressure by means of a lever acting through friction rollers. Arrangements are made for recording the number of revolutions of both cylinders; and connected with both spindles are driving pulleys and friction breaks on Appold's system, by means of which the force to be transmitted can be regulated.

An amount of slipping of not more than the one hundred thousandth part of the distance rolled can be measured with this machine.

The machine was constructed in Owen's College by Mr. Foster.

IX.—MEASUREMENT OF WORK.

429. Dynamometer, graduated up to 100 kilogrammes by intervals of 200 grammes, and showing dynams in kilogrammetres up to 981, each interval measuring two dynams nearly in absolute measure. *Prof. Hennessy, Dublin.*

430. Dynamometer graduated up to 10 kilogrammes, and giving absolute dynams in kilogrammetres up to 98, each interval measuring nearly one dynam in absolute measure.

Prof. Hennessy, Dublin.

Dynamometers similar to these are are employed at the Royal College of Science. Dublin, as referred to in the College Directory for 1876–77, page 17.

"The dynam or unit of force commonly employed throughout the course is one kilogramme moving through one metre in one second of time."

430a. Photograph of Electrodynamometer. Made by Professor H. A. Rowland, Johns Hopkins University, Baltimore, on the model of that of the British Association.

Cavendish Laboratory, Cambridge.

431. Drawing of a Dynamometrical Apparatus, constructed in 1844 by the exhibitor, to measure the real horse-power of steam-boats. *Prof. Daniel Colladon, Geneva.*

This apparatus, approved by the Academie des Sciences in 1843, was, in the same year, adopted in the Royal Dockyard at Woolwich.

644. Surface Spring Indicator.

H. Hädicke, Demmin, Pomerania.

The indicator was constructed by the exhibitor, and executed from his drawings by Messrs. Blanche and Co., in Merseburg. The piston has been replaced by a surface spring, and the construction aims at—

1. Avoiding the friction of the piston of the indicators hitherto in use.
2. Avoiding the slackness of the piston.
3. Avoiding the points of the diagram of machines in rapid motion produced by the mechanical momentum of the piston.

432. Richard's Patent Steam Engine Indicator, with Darke's Patent Detent and Cord Adjuster. *Elliott Brothers.*

By means of the detent, the paper cylinder is instantaneously set in motion or stopped by the movement of the pencil arm, as it is being applied or withdrawn, giving great facilities for taking a number of consecutive diagrams, also rendering its application to oscillating engines much more convenient.

433. Cooper's Patent Slide Valve Indicator. An instrument for ascertaining the relative position between the piston and slide valve of an engine at different points of the stroke.

Elliott Brothers.

434. Flexion Pandynamometer. An instrument designed to determine the work done by a steam engine, by means of the flexion of the beam. *G. A. Hirn.*

On the upper edge of the beam is a rigid wooden bar of the same length, resting in the centre on a fork which prevents it from swerving, fastened to one end of the beam with an iron rod, and free at the other end. To this extremity is attached an inelastic cord, which passes round a pulley, fixed at the head of the beam, and is carried thence towards the centre, where it is wound round the axis of a very light needle.

It is evident, from this arrangement, that when the beam moves in either direction, the end of the wooden bar which remains rigid approaches to or recedes from the head of the beam. The cord consequently winds itself round, or unwinds itself from, the axis of the needle, and the deviation of the latter indicates the degree of flexion of the beam, multiplied if desired. At the end of the needle is fixed a pencil, which works on a small board placed above the beam. This pencil, at each double stroke of the piston, traces a closed curve, of which the ordinates indicate the successive degrees of flexion of the beam during the work. To determine, once for all, the degree of flexion corresponding to a given load, the crank of the fly-wheel should be fixed at the dead point, and steam at a known pressure should be introduced into the cylinder.

435. Torsion Pandynamometer. This instrument is designed to measure the power supplied by an engine to a factory, by means of the torsion of the shafting through which the motive power is transmitted. *G. A. Hirn.*

At the extremities of one length of the shafting are keyed two toothed wheels of equal diameter, which gear, one directly and the other by an intermediate wheel, into two smaller pinions. These pinions gear into the four bevelled wheels of an ordinary differential movement. The two intermediate wheels of this movement are loose on a shaft, which is prolonged in a vertical direction, and made of a light steel rod. The result of this arrangement is, that if the shaft twists, this rod deviates, and forms with a vertical line an angle proportionate to the torsion to which the shaft is subjected. At the upper and free extremity of the steel rod is secured, by means of a hinge, a horizontal very light wooden bar, carrying at its extremity a roller, to which is attached a recording apparatus. This roller, when the shaft is at rest, lies in the centre of a wooden disc covered with paper, and revolving uniformly on a vertical axis.

So soon as the steel rod deviates from a vertical line, in consequence of the torsion of the driving shafting, the roller leaves the centre of the disc, and begins to revolve. The turns registered by the recording apparatus are exactly proportional to the torsion of the shafting.

The mean torsion of the shafting being thus known for a day's work, two parallel levers, placed in contrary directions, are securely fixed at the extremities beyond the two toothed wheels, and the free extremities of the levers, so as to determine the deviation caused in the vertical bar by a given weight.

Simple proportion then gives the resistance, corresponding to the mean angle obtained during a day's work, and it becomes easy to determine the mechanical work which corresponds to this angle.

435b. Dynamometer Waggon, for marking and registering the tractive power, and the distances travelled.

Eastern Railway of France Company, Paris.

436. Theoretical Pressure Diagram for calculating the mechanical work in a steam cylinder.

H. Hädicke, Demmin, Pommerania.

X.—MEASUREMENT OF ANGLES.

437. 10-inch Protractor, by Ramsden. *Royal Society.*

438. Clinometer of Precision, employed in 1865 by Professor Piazzi Smyth in the interior of the Great Pyramid.

Prof. Piazzi Smyth.

This instrument was made to order by T. Cooke and Sons, of York, in 1864, at the cost of Andrew Coventry, Esq., of Edinburgh, for measuring the interior slopes of the Great Pyramid. When thus used it was further mounted on a deep wooden beam, 120 inches long, armed with feet of gun metal.

The angle measuring portion of the instrument is a complete circle, provided with three pairs of opposite verniers, each reading to 10″ in order to eliminate errors of division as well as eccentricity, and the whole circle can be moved and clamped on its centre so as to repeat any required angle all round the circumference. On the voyage to Egypt a thermometer broke inside the box, and the mercury tarnished the divided rim in parts. The Pyramid angles thus obtained were printed in Vol. II. of "Life and Work at the Great Pyramid," by Professor Piazzi Smyth, in 1867.

439. Smaller Clinometer of Precision, with improved mounting, readers, and level. *Prof. Piazzi Smyth.*

This instrument was made to order by E. E. Sang, of Edinburgh, in 1869, and intended for measuring Great Pyramid angles of slope. It carries its own footbar, 25 inches long, has improved readers and illuminators, and a chloroform level, as being more quick and frictionless than either ether or alcohol. The circle can be rotated and clamped on its own centre for due repetition of the angles round the circumference; the verniers read to 1′, and there are supplementary verniers for investigating errors of division.

435a. Method of ascertaining **Angles of Torsion** by means of instruments constructed by Professor Wischnegradski.

Laboratory of Mechanics, Technological Institute, St. Petersburg.

This is composed of a support fixed with two horizontal screws in the given section of the beam subjected to torsion. This support carries a horizontal axle, upon which is fixed an arc, bearing the teeth, whose pitch measures an angle of 2,440 seconds. This arc gears with an endless screw, the head of which bears a circle divided into 244 equal parts, and furnished with a fixed decimal vernier; the arc also carries a very sensitive level, placed at the beginning of the experiment in a horizontal position.

The angle of torsion between the two given sections of the beam is calculated by two instruments exactly similar. The deformation of the twisted beam causes an inclination of the levels of both instruments; they are restored to their original position by means of the endless screws, and then is effected the reading of the angles described by the arcs of the two instruments. The difference between these angles is the angle of torsion required.

In the Laboratory of Mechanics of the Technological Institute of St. Petersburg the well-known apparatus of Wöhler is used for the torsion of trees, the photograph of which, taken together with the instruments for measuring the angles of torsion, is exhibited. For demonstrating how to use the instruments, a provisional apparatus is exhibited, wherewith the torsion of the beam is effected by means of a simple lever.

442. Clinometers, devised by the Rev. Professor Henslow, one of which was used by Dr. Hooker in his Himalayan journeys. *J. D. Hooker, M.D., P.R.S.*

442a. Three Clinometers. *G. W. Strawson.*

443. Protractor, with scale, vernier, and magnifying glass. Reads to 1 min. *Prof. Baron von Feilitzsch, Greifswald.*

443b. Instrument for the Measurement of Angles. *Dr. Fr. Holler, Selbo Drontheim, Norway.*

440-1. Drawings and Photographs of Dividing Machinery. *Messrs. Troughton & Simms.*

Fig. 1. General view of dividing machine.
- A. The circular table with racked circumference containing 4,320 teeth, each tooth, therefore, equal to five minutes of arc.
- B. The screw by which movement is communicated to Table A.
- C. A ratchet wheel attached to the screw shaft.
- D. A crank arm which during one half of a revolution gives a forward movement to the screw; during the remaining part of its revolution the screw is at rest. The axis which carries the crank arm has a bevelled wheel upon it, serving to communicate motion to the cutting apparatus.
- E. The cutting frame.
- F. A cam to give movement to the dividing knife or other tool by which the division is made.

  The apparatus is so arranged that the division may be cut whilst the circular table is at rest, the tool being lifted by a second cam (not well seen in the drawing) when the table is in motion.

Fig. 2. Plan of cutting apparatus showing the relation it bears to the circular table and screw.

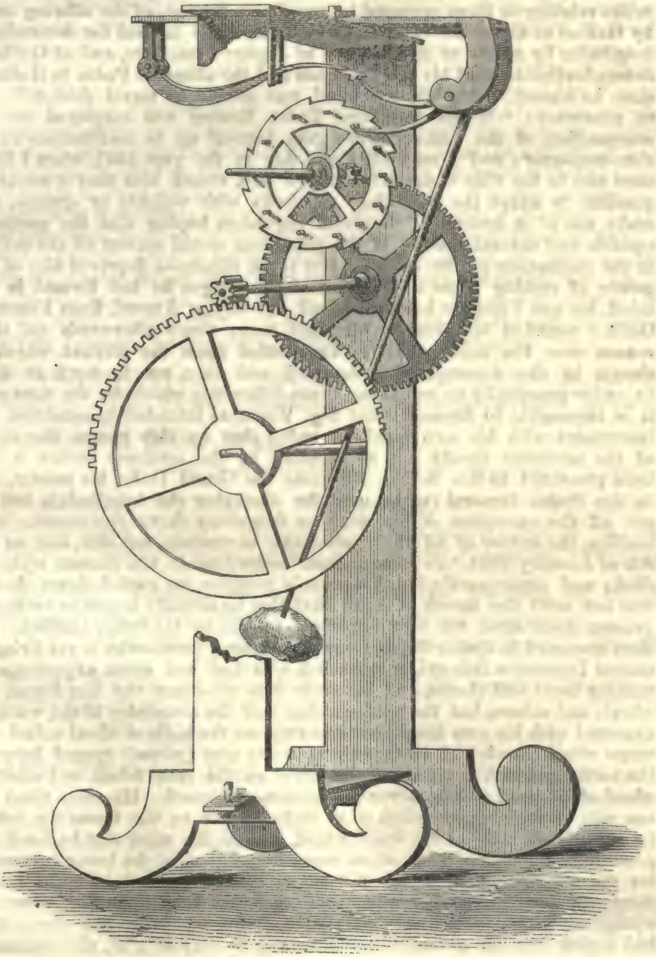
Fig. 3. Section of table and axis.

Fig. 4. Drawings of cams and cutting frame, the cam "h" for lifting the tool (just seen in Fig. 1) is here shown.

XI.—MEASUREMENT OF TIME.

Copy of the **Drawing representing the first idea of the Application of the Pendulum to the Clock; dictated by Galileo,** then blind, to his son Vincenzo and his disciple Viviani. Elucidated on the original of the Galilean manuscripts in the Biblioteca Palatina.

The Royal Institute of "Studii Superiori," Florence.



In an account which he gave Prince Leopoldo de' Medici, Viviani, after having described Galileo's experiments on the pendulum, and the way in which he applied it to the measurement of time, continues thus: "But as "Galileo was most liberal in communicating his inexhaustible speculations, "it frequently happened that the uses and newly discovered properties of "his pendulum, spreading little by little, fell into the hands of persons who "adopted them for their own ends or inserted them in publications, and "by artfully passing in silence over the name of their true author, made "such use of them that it was believed—at least by those who knew nothing "of the origin of the discoveries—that the writers were the real authors of "them. He next speaks of the observations of the 'Stelle Medicee,' of the "tables relating to them prepared by the Padre Renieri, of the offering made "by Galileo to the States General of Holland of his method for determining "longitudes by means of the eclipses of Jupiter's satellites, and of Galileo's "determination to send his son Vincenzo and the aforesaid Padre to Holland, "since he himself, being old and blind, was unable to travel thither." He then continues: "While, therefore, Padre Renieri was employed on the "composition of the tables, Galileo gave himself up to meditations on his "time-measurer; and I remember, one day in the year 1641, when I lived "near him in the Villa d'Arcetri, that the idea struck him that it would be "possible to adapt the pendulum to clocks with weights or springs, and "make use of it instead of the usual regulator, hoping that the perfectly "equable and natural motion of the pendulum would correct all the defects "in the mechanism of the clocks. But as his blindness deprived him of the "power of making plans and models of the designs he had formed in his "mind, his son Vincenzo having arrived one day at Arcetri, from Florence, "Galileo confided his ideas to him, and many times afterwards did they "reason over the matter, and at last settled upon the method which is "shown in the accompanying drawing, and then set to work at once "in order practically to overcome those difficulties which for the most part "it is impossible to foresee. But Sig. Vincenzo intended to construct the "instrument with his own hand, in order that by this means the secret "of the invention should not be reported by the artificers before it had "been presented to His Serene Highness the Grand Duke, his master, and "to the States General (to be used for observing the longitude), but he "put off the execution of his work so frequently that a few months later "Galileo, the author of all these admirable inventions, fell sick, and on the "8th of January 1641, 'ab Incarnazione' according to the Roman style, he "died; and consequently Sig. Vincenzo's energies so cooled down that it "was not until the month of April 1649 that he actually began to make the "present clock upon the idea explained to him by his father Galileo. He "then managed to obtain the services of a young man—who is yet living— "named Domenico Balestri, a locksmith who had had some experience in "making large wall clocks, and he made him construct the iron frame, the "wheels and arbors, but the tooth-cutting and the remainder of the work he "executed with his own hands, constructing on the highest wheel called the "scape wheel (*tacche*) 12 teeth with as many pins (*pironi*) spaced between "the teeth, and with a pinion of six leaves on the same arbor, and another "wheel of 90 teeth which moves the above-mentioned. He then fixed on "one side of the support which is at right angles to the frame the detent "(*scatto*) which rests on the scape wheel, and on the other side he fixed the "pendulum, which was made of an iron wire screwed at the lower extremity "for the attachment of a ball of lead, so that it could be lengthened or "shortened for regulating. When this much had been done Sig. Vincenzo "wished me (as one who was in the secret of this invention and who indeed "had urged him on to complete it) to see, by way of trial, the combined

" working of the weight and the pendulum. I observed the mechanism in " operation more than once, and his workman was likewise present. When " the pendulum was at rest it prevented the descent of the weight, but when " it was raised and then let go, in passing beyond the perpendicular, with " the longer of the two arms attached to the pivot of the pendulum, it raised " the detent which fits into the scape wheel, which wheel drawn by the weight " in rotating with its higher part moving towards the pendulum, pressed with " one of its pallets on the other shorter arm, and gave it, at the beginning of " its return, an impulse sufficient to cause it to swing to the height from " which it had started, so that when it fell back naturally, and had passed " the perpendicular, it returned once more to lift the detent, and immediately " the scape wheel was set in motion and gave a fresh impulse to the pendulum, thus, the swinging of the pendulum was rendered continuous until " the weight had reached the ground. We examined the operation together, " connected with which, however, many difficulties arose; but Sig. Vincenzo " did not doubt but that he would be able to overcome them all, indeed he " fancied that he would be able to apply the pendulum to clocks in a different " manner and by means of other inventions; but since he had got so far, he " wished to finish it on this plan, as the drawing shows it, with the addition " of hands to show the hours and even the minutes. For this purpose he set " to work to cut another cog-wheel. But whilst engaged on this work to which " he was unaccustomed, he was overtaken by a very acute attack of fever, and " was obliged to leave it unfinished at this point, and on the 22nd day of his " illness, on the 16th of May 1649, all his thoughts and aspirations, together " with this most exact measurer of time, were for ever lost to him. He, " their author, passed away to measure (let us hope) in the enjoyment of the " Divine Essence, the incomprehensible moments of Eternity."

Dodecahedron, with eleven solar watches, made in Florence in 1587. *The Royal Institute of " Studii Superiori," Florence.*

Horizontal Solar Watch.
The Royal Institute of " Studii Superiori," Florence.

Horizontal Watch, at the latitude of 43° 44′, made by Cammillo della Volpaja, Florentine, in the second half of the 16th century. *The Royal Institute of " Studii Superiori," Florence.*

Vertical Watch, of boxwood, at the latitude of 43° 30′, made in Florence in 1590 by Girolamo della Volpaja.
The Royal Institute of " Studii Superiori," Florence.

Night Watch, at the latitude of 43° 30′, made in Florence in 1568 by Girolamo della Volpaja.
The Royal Institute of " Studii Superiori," Florence.

483. Universal Dial, made in 1616 for Prince Charles.
The Royal United Service Institution.

Presented to the United Service Museum, in 1832, by Captain W. H. Smyth, R.N., K.F.M., F.R.S., &c., &c.

485. Universal Dial, in use about 160 years ago.
The Royal United Service Institution.

Presented to the United Service Museum in 1838, by His Royal Highness the Duke of Sussex.

484. Timekeeper, which was twice carried out by **Captain Cook.** *The Royal United Service Institution.*

This timekeeper is thus spoken of in Cook's Voyage to the Pacific, 1776, Vol. I., p. 4: "I had likewise in my possession the same watch or time-"keeper which I had in my last voyage, and which had performed its part "so well. It was a copy of Mr. Harrison's, constructed by Mr. Kendall."

This watch was taken out again by Captain Bligh, 1787, and when the crew of the "Bounty" mutinied it was carried by the mutineers to Pitcairn's Island. In 1808 it was sold by Adams to an American, Mr. Mayo Fletcher, who sold it in Chili, and in 1840 it was purchased for fifty guineas by Sir Thomas Herbert. It was repaired and rated at Valparaiso, and taken by Sir Thomas to China, and brought home in the "Blenheim" in 1843, having kept a fair rate with the other chronometers for the space of three years.

Presented to the institution by Admiral Sir Thomas Herbert, K.C.B.

484a. Two Hour Glasses. These were used in Spanish men-of-war at the beginning of the last century.

Ministry of Marine, Madrid.

484b. Chronometer, the fifth made by the English maker Arnold. It was used on board one of the Spanish ships at the battle of Trafalgar. *Ministry of Marine, Madrid.*

491. Ancient Striking Clock.

H. M. Commissioners of Patents.

This clock is of Swiss manufacture, and supposed to have been made in the year 1348. It was obtained from Dover Castle, and had never been removed from there till the year 1872. It is interesting from the fact of its having the verge escapement, which was used many years before the pendulum.

444. Clock Dial. The hours, six only, are indicated by perforated Roman letters. The hand or pointer is formed of a revolving disc, painted in oil, with the subject of Aurora and the Hours; it must have gone round four times in 24 hours. The dial is fitted in the original carved door of the clock. *Italian.* 17th century. *Rev. J. C. Jackson.*

445. Clock, in the shape of an orb of silver-gilt, covered with silver filigree, suspended from a ring which is surmounted by a cupid. The base of black marble is ornamented with beads enriched with silver-gilt filigree, enamels, and precious stones. *German* (*Hamburg*). Dated 1685.

Rev. J. C. Jackson.

446. Clock, in gilt ormolu case, engraved with figures of soldiers and festoons of flowers and fruit. It has a single hand, and strikes the hours. The present pendulum has been substituted for the old bob. *English.* Early 17th century.

Rev. J. C. Jackson.

462. Model of a Clock with four Faces, to be worked by water. *Major M. L. Taylor, R.A.*

463. Sir W. Congreve's Clock, in which the action of the pendulum is replaced by the motion of a small steel ball on an inclined plane, which it descends in 30 seconds.
Major M. L. Taylor, R.A.

486. Month Equation Clock, with double pendulum and dead-beat escapement by Quire, showing minutes and seconds both sidereal and mean time, also sun fast or slow, and containing an annual almanack, mentioned in Cooke & Maule's account of Greenwich Hospital in 1789. *Royal Naval College, Greenwich.*

447. Two Chronometers, by Arnold. *Royal Society.*

These chronometers were taken round the world by Captain Cook.

447a. Chronometer, with **Glass Balance Spring.**
E. Dent and Co.

This is the invention and handiwork of the late Frederick Dent, of the Strand and Royal Exchange, and the only specimen in existence. The spring requires far less compensation for any given change of temperature than a steel spring would, and the balance, which is composed of a glass disc, is compensated by the two small compensation laminæ mounted upon it.

448. Explanation of the principles of action of the **Compensation Balance,** with four models showing the various stages of construction. *James Poole & Co.*

"Cut open" for action of heat and cold; ordinary construction without auxiliary, in rough state from casting.

450. Silver Pocket Chronometer. *James Poole & Co.*

451. Diagrams and Models of the method of winding and setting watches without a key. *James Poole & Co.*

452. Keyless Watch, complete, with fuzee.
James Poole & Co.

452a. Dipleidoscope with Telescope. *M. Lutz, Paris.*

453. Keyless Watch, complete, with centre seconds and going barrel. *James Poole & Co.*

454. Ship Chronometer (2 day), complete.
James Poole & Co.

455. Ship Chronometer (2 day). Movement reversed, to show workmanship. *James Poole & Co.*

456. Chronometer Movement (2 day), as received from the factories in Lancashire. *James Poole & Co.*

456a. Six Chronometers with rates from the Geneva Observatory, stating records of trials of the years 1875 and 1876.
H. R. Ekegrén, Geneva.

No. 16,175, gold, open face, 21 lines, keyless.
No. 16,873, „ „ 18 „ „
No. 16,144, „ „ Chronographs, 19 lines, keyless.
No. 16,534, „ hunter, 21 lines, keyless.
No. 16,576, „ „ 19 „ „
No. 16,525, „ „ 18 „ „

457. Regulator Clock, filled with the Exhibitor's new patent gravity escapement, having no upward locking, and which cannot trip or slip teeth. *Alfred John Higham.*

On the escape wheel there are two sets of teeth, one set longer than the other; the teeth of each set are arranged, and the pallets are formed and placed, so that the shorter set of teeth only is used, except in case of tampering or other disturbance, when the longer set comes into action. This secondary locking entirely prevents irregularity in the clock rate, but the clock can be allowed to "run," if it is desired to be so set to time, by removing two extra stops which are adjustable. The action of the escapement is ordinarily exactly the same as that of the gravity escapements invented by Mr. Denison (Sir Edmund Beckett, Bart.), and the secondary locking can be applied to those escapements. For further description, see the Horological Journal, April 1876.

458. Regulator, with improved gravity escapement on the Bloxamic principle, as arranged and patented by Mr. Higham; founded on the old pin-wheel escapement, and fitted with a galvanic interruptor for chronographical and other astronomical purposes. *Charles Frodsham & Co.*

459. Marine Chronometer, fitted with a galvanic interruptor for chronographical and other astronomical purposes.
Charles Frodsham & Co.

459a. Two-day Marine Chronometer, fitted complete for ship's use. *Charles Frodsham.*

460. Apparatus for demonstrating the application of the pendulum to the clock, at the same time serving for audibly indicating the minutes.
The Secondary Government School, Assen (Netherlands).

This apparatus is constructed by C. H. Van der Heyden, watchmaker, at Assen (Netherlands), in conjunction with Dr. A. Van Hasselt, teacher at the school for middle-class education, Assen. Price about 4*l*. The escapement may be pulled forward so as to allow the wheel to turn freely. In this manner it may be demonstrated, that clockwork without a pendulum will acquire an accelerated motion.

The escapement must be kept in a forward position, until the weight has reached the ground.

The apparatus, as it audibly indicates the minutes, may also be used for experiments to demonstrate the laws of the pendulum, the laws of hydrodynamics, &c.

460a. Wheatstone's Motor Magneto-Electric Clock (in teak case). *The British Telegraph Manufactory, Limited.*

460b. Wheatstone's Sympathetic Magneto-Electric Clocks (4). *The British Telegraph Manufactory, Limited.*

460c. 18-inch Wheatstone's Sympathetic Magneto-Electric Clock.

The British Telegraph Manufactory, Limited.

461. New System of Electric Clocks.

Prof. Osnaghi, Imperial Central Meteorological Institute, Vienna.

In these electric clocks the uncertainty of the action of the greater number of electric pointers has been avoided by causing the electric current to flow with almost unabated force, as if there were no other clocks present. This is attained by giving the electro-magnets double coils of very unequal resistance. The spirals with great resistance serve for the attraction of the needle from a distance; the spirals with little resistance for retaining the already attracted needle. With every clock there is also a wire coil for the general return current, through which the electric current can circulate until the attraction of the needle is complete, when its course is diverted by certain mechanism, and is forced to pass over to the next clock.

464. Model of a Protomotive Clock.

The Committee, Royal Museum, Peel Park, Salford.

An apparatus consisting of a dial with hour and minute hands, and a gutta-percha tube 100 feet in length, the object of which apparatus is to demonstrate how a number of such dials in distant situations may be made, by means of a column of air at natural pressure, to indicate the same time as the clock with which they are connected. Invented and made by the late Richard Roberts, C.E., Manchester, about the year 1848.

465. Ley's Compensating Pendulum. *Henry W. Ley.*

An inexpensive pendulum compensation is to be obtained by the employment of zinc and flint glass.

466. Ley's Entirely Detached Gravity Escapement.

Henry W. Ley.

The object of this escapement is to cut off absolutely from the pendulum the clock train with its variations, so that there may be nothing whatever to disturb the arc of vibration. The arrangement of the escapement shown in the Figs. permits the motions of the various parts to be clearly followed. The scape wheel has six long teeth A, Figs. 1, 2, 3, and 4, by means of which it is "locked," and six "impulse" pins B near its arbor. The arbor carries a fly, not drawn. The pendulum receives its impulse at each alternate beat; at the beats from right to left in the Figures. The parts of the escapement are: (1), a pallet C; (2), a lever D, having the same axis as C, and resting normally against a fixed stop, from which it can lift, but below which it cannot fall; (it is in its normal position in Figs. 1, 3, and 4); (3), an arm E, of which one end can turn on a pin in D, and the other end, which is free, is lifted by the impulse pins, and rests on them successively; (it is resting on an impulse pin in Fig. 1); (4), a first detent F, against which C sets when at the top of its lift; (C is thus set against F in Fig. 1); (5), a second detent G; and (6), set on a spring, a stop H, against which the scape wheel locks.

Fig. 1.—The pallet against the first detent.

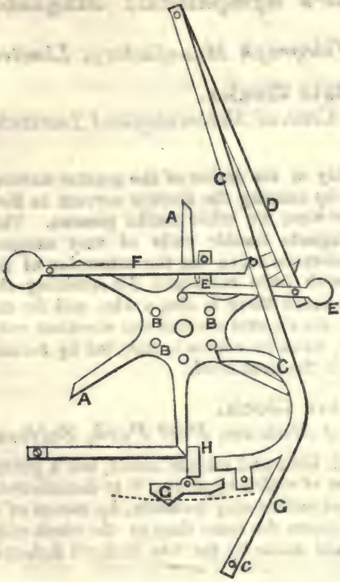
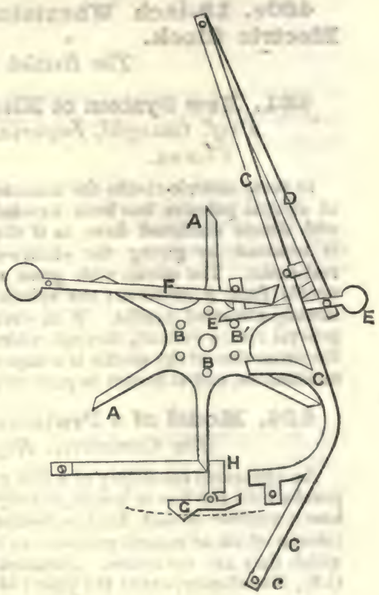
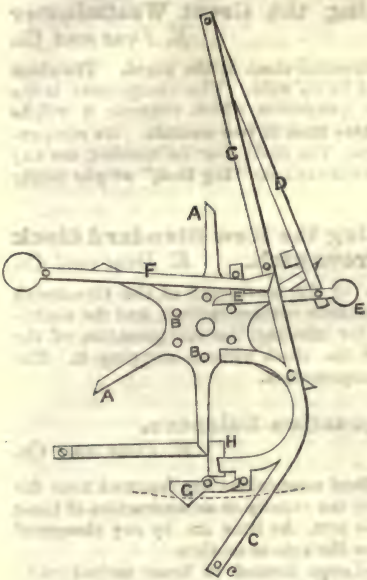


Fig. 2.—At the end of the pendulum swing to the right.



The action of the escapement is as follows:—Suppose (as represented in Fig. 1) the scape wheel to be locked and that C has been lifted from its lowest position through an angle $\alpha + \beta$ to the top of its lift. Suppose also that the pendulum is moving to the right from the end of its swing at the left. First, a slot or a pin in the pendulum rod (a pin is supposed here for simplicity sake, and the path of the pin is shown by the dotted curve in each Fig.) lifts G, idly, which falls back to its normal position, that of Fig. 1, immediately the pin has passed; then the rod itself, towards the end of its swing to the right, impinges against a "beat" pin *c* in C, and, still rising, carries C with it through a further angle γ. In rising through γ, C takes up D, and the free end of E, which was resting on the impulse pin by which it was lifted, is carried clear of that pin (now see Fig. 2), and drops on to B^1, the impulse pin next below, depressing F in its drop, and afterwards holding F down (see E and F in same Fig.). The pendulum now returns, from right to left, and C with D falls back through γ, D being arrested at the fixed stop; the free end of its arm E still resting on B^1, and still holding F down. The pendulum continuing its descent, C falls back through β (the detent F being out of the way), as far as the detent G (here see Fig. 3), where it stops. In this fall through β, C gives the impulse. The pendulum now moves on by itself, until presently the pin in its rod once more lifts G; not, however, idly now, but releasing C, which falling back further through α to its lowest position (shown in Fig. 4), unlocks the scape wheel from H. The position of H with respect to that part of C which acts upon it is

Fig. 3.—The pallet against the second detent.



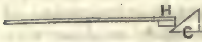
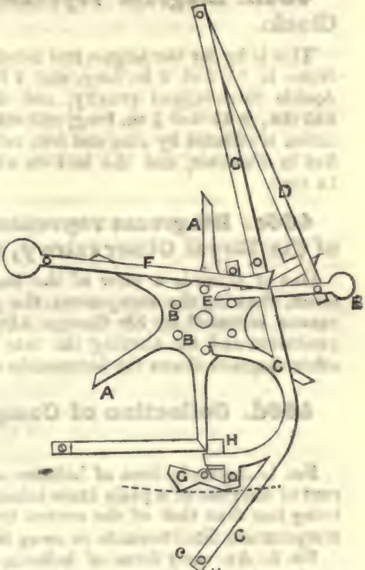


FIG. 3a

Fig. 4.—The pallet at its lowest position.



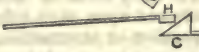


FIG. 4a

shown in plan in Figs 3*a* and 4*a*; in Fig. 3*a* just before, and in Fig. 4*a* just after the unlocking of the scape wheel. The pendulum having lifted G, continues its swing to the extreme left, whence it was supposed started. The scape wheel, free to move, lifts C and also E, the detent F, which is weighted so as to rise of itself, following E's motion, and being in position to hold C when the lifting is done, which is the case just before the next long tooth of the scape wheel coming round and setting against H (which returned to its normal position as C in lifting cleared it), the parts are again as represented in Fig. 1.

Such being the action, it is evident that the escapement is not only a detached one in the sense in which all properly so-called gravity escapements are so, that is, the pendulum is free from the scape wheel between the unlockings, but that the detachment is entire, seeing that the pendulum is *never in connexion with the clock-train at all*, being out of the way for the unlockings, as well as between whiles. There is therefore nothing whatever to affect its rate.

The pressure of the scape wheel against the stop by which it is locked varies. This variation, however, is altogether apart from the pendulum, as unlocking is the work of the pallet.

In the arrangement drawn the impulse is not given across the line of centres; it can, however, be so given; and other modifications of the escapement as here arranged can be made within the limits of its principles of action, which are (1) that the lifted pallet shall be held independently of any variations in the lift, and (2) that the unlocking shall be apart from the pendulum.

466a. Jamin's Compensator. *M. Lutz, Paris.*

466b. Diagram representing the Great Westminster Clock. *E. Dent and Co.*

This is by far the largest and most powerful clock in the world. The clock frame is 15 feet 6 in. long, and 4 feet 10 in. wide. The escapement is the double three-legged gravity, and the pendulum which controls it weighs 685 lbs., is 14 feet 5 in. long, and vibrates once in two seconds. Its compensation is effected by zinc and iron tubes. The dials, four in number, are 22½ feet in diameter, and the bell on which it strikes, "Big Ben," weighs nearly 14 tons.

466c. Diagrams representing the New Standard Clock of the Royal Observatory, Greenwich. *E. Dent and Co.*

One of these is a view of the back of the movement of the Greenwich clock, showing the escapement, the galvanic contact springs, and the contrivances invented by Sir George Airy for altering the compensation of the pendulum and for altering the rate of the clock without stopping it. The other diagram shows the barometric compensation.

466d. Collection of Compensation Balances. *E. Dent and Co.*

No. 1. An early form of balance.—Steel connexions are fastened near the root of the rims of a plain brass balance; the expansion or contraction of these being less than that of the central brass arm, the rims are by any change of temperature tilted towards or away from the axis of motion.

No. 2. An early form of balance.—Loops formed of brass melted on to steel are fastened upon each side of the axis of motion, in consequence of the greater expansion or contraction of the brass, these open or close with the change of temperature, and drag in or thrust out the small brass weights, to which they are attached by wires.

No. 3. An early form of balance.—The rims are of brass melted upon steel, the brass being outwards; with any change of temperature the rims open or close.

No. 4. An early form of balance.—A flat steel bar has soldered to its extremities underneath pieces of brass; the ends of the steel bar carry uprights bearing weights upon their summits, the brass pieces underneath having a different rate of expansion to the steel, bend it either upwards or downwards, and tilt the uprights carrying the weights towards or away from the axis of motion.

No. 5. A balance of similar design, but having brass melted upon the steel, instead of merely being soldered to its extremities.

No. 6. A balance of modern design, similar in its action to No. 5.

In order to obtain perfect compensation, it is found that for an increase of temperature the compensation weights must advance more rapidly towards the axis of motion, than for the same decrease of temperature they would recede from it. This peculiarity necessitates what is called secondary compensation. The following balances have been introduced to obviate this error:—

No. 7. Compensation pieces formed of brass melted upon steel receive such curves, that with any increase of temperature the compensation weights move towards the axis of motion more directly than they recede from it with any decrease of temperature. (Dent's balance.)

No. 8. A compensation bar is formed, as in No. 5, by brass being melted upon steel, and this bending upwards or downwards, with any change of temperature, tilts the weights carried by the staples towards or away from the axis of motion. But the staples are themselves compensation pieces, and they lift the weights higher with any increase, and depress them with any decrease of temperature, and in this manner increase the rate at which they approach the axis of motion, and diminish the rate at which they recede from it. (Dent's patent balance.)

No. 9. A balance of nearly the same form as No. 6, but the section of its rim is somewhat in the shape of a prism; the form of the rim offers less resistance to the motion of the compensation weight inward than outward. (Dent's registered balance.)

No. 10. A balance similar to No. 5 is mounted upon the arm of a balance similar to No. 6. With any increase of temperature, the first balance can assist the second, but with any decrease of temperature its motion is checked. The whole combination, therefore, is more effective in the heat than in the cold. (Glover's form.)

No. 11. An experimental balance, contrived for the purpose of removing weight from the centre, both with an increase and decrease of temperature. (Wetherill's form.)

No. 12. An auxiliary compensation is added to a balance similar in form to No. 6. The auxiliary consists of two double compensation pieces, and the effect is to carry weight towards the axis of motion, both for an increase and decrease of temperature. The effect of the main compensation weights is therefore increased in the heat and diminished in the cold. (Dent's balance.)

No. 13. A balance of similar design to No. 8, but arranged so that the secondary compensation can be altered with greater facility. (Dent's balance.)

No. 14. A balance having the same general operation as No. 8, but the effect is obtained by straight bars only. The secondary compensation can also be altered without inconveniently disturbing the main compensation, and both without producing any great alteration in the time of the chronometer. (Dent's balance.)

467. Drawings of Compensation Balances, Escapements, and other appliances connected with the construction of Clocks and Watches. *The British Horological Institute.*

Lever Escape Wheel.
Lever Escapement.
Double Roller Lever Escapement.
Two Pin Lever Escapement.
Chronometer Escapement.
Duplex Escapement.
Club Tooth Lever Escapement.
Verge Escapement.
Horizontal Escapement.
Double Roller Lever Escapement with Compensation Balance.
Marine Chronometer Escapement.
Compensation Adjustment by Sir G. B. Airy, Astronomer Royal, 1875.
Double Three-legged Gravity Escapement as used in the Westminster Great Clock.

Dead Beat Clock Escapement.
Pin Wheel Clock Escapement.
Zinc and Steel Compensation Pendulum as used in the Westminster Great Clock.

467a. Compensation Balance arranged in Two Groups.

GROUP I.—Earnshaw's balance with circular rim (1795), and modifications thereof to the present time.

Earnshaw's balance.
Modification of do.
Do. do.
Do. do., with extra adjusting screws.
Do. do., with screws for weights.
Do. do. do. do.
Do. do., with screws for more minute adjustment.
Do. do. do. do. do.
Do. do., with double weights.
Do. do., with variation of weights.
Do. do., with auxiliary by Molyneux.
Do. do., do. do.
Modification of Molyneux's auxiliary.
Eiffe's mercurial auxiliary.
Poole's auxiliary.
Example of recent auxiliary.
Do. do. do.
Do. do. do.
Compensation adjustment by the Astronomer Royal (Sir G. B. Airy).

GROUP II.—Balances of a form distinct from Earnshaw's, from Hardy (1805) to the present time.

Hardy's balance.
Arnold's do.
Dent's do.
Balance with laminated arm and rim.
Hartnup's balance.
Do. do. cup.
Modification of Hartnup's balance.
Kullberg's flat rim balance.
Do. double-flat rim balance.
Cole's balance.

The British Horological Institute.

468. Enlarged Model of Compensation Watch Balance.
The British Horological Institute.

469. Ordinary Marine Chronometer Compensation Balance. *The British Horological Institute.*

471. Models (ten) **of Compensation Balances,** showing various attempts to overcome what is known as the "Error" of the ordinary Compensation Balance, by the late Thomas Hewitt.
The British Horological Institute.

472. Marine Chronometer by Earnshaw.
The British Horological Institute.

473. Marine Chronometer with Mudge's Escapement.
The British Horological Institute.

474. Grossmann's Micrometer.
The British Horological Institute.

475. Model of "Ferguson's Paradox."
The British Horological Institute.

476. Model of Cole's Resilient Escapement.
The British Horological Institute.

477. Callipering Engine, by the late Richard Roberts.
The British Horological Institute.

478. Models of English and French Repeating Motions for Watches. *The British Horological Institute.*

479. Watch Movement.
The British Horological Institute.

480. Marine Chronometer Movement.
The British Horological Institute.

481. Collection of Watch and Chronometer Balance Springs. *The British Horological Institute.*

482. Map showing allowance of time to be made for velocity of sound as applied to the **Westminster Clock Bell.**
The British Horological Institute.

482a. Working Model, for educational purposes, of a Chronometer Escapement, with a 6-inch compensation balance. *Ignaz Herrmann.*

482b. Working Model, for educational purposes, of a Lever Watch Escapement. *Ignaz Herrmann.*

Working Model, for educational purposes, of a Horizontal Watch Escapement. *Ignaz Herrmann.*

Model for demonstrating the law of the compensation balance or of any vibrating or rotating body. *Ignaz Herrmann.*

An arm carrying movable weights revolves about a vertical axis under the action of a spring. The time taken for the spring to run down is proportional to the square root of the distance of the weights from the axis.

484a. Eight-day Marine Chronometer.
Parkinson & Frodsham.

484b. Eight-day Marine Chronometer.
Parkinson & Frodsham.

484c. Chronometer, used by Captain Parry in the year 1819. *Parkinson & Frodsham.*

This chronometer, used by Captain Parry in his voyage to the Polar Sea in 1819, was specially compensated for extreme cold. Others of a similar character were recently made for the Arctic Expedition under Captain Nares; also for Dr. Livingstone's Central African Expedition, the latter being compensated for a higher range of temperature.

487. Pendulum Clock for marking the time according to the time system of nature, thus forming the standard of a system of measurement including time and space together, with decimal subdivisions. The pendulum measures space by its length, and time by its period of oscillation.
Hans Baumgartner, Basle, Switzerland.

The pendulum has the exact length of a longitudinal unit of natural measure, that is to say, of the one hundred thousandth part of a degree, of which 540 go to a meridian, and measures the natural second, or the one hundred thousandth part of a mean day.

487a. Pendulum. *Professor Dr. A. Krueger, Helsingfors.*

A barometer tube of about 350^{mm} length is attached to the pendulum rod in the plane of swinging; a little quantity of dry air is introduced in the upper part of the tube: height of the mercury column about 150^{mm}. The rising and falling of the mercury, depending on the variations of atmospherical pressure, will affect the length of the pendulum and the clock-rate. It will be very easy to calculate the distance from its centre, at which the tube is to be attached; then the barometrical variation in the clock-rate will be compensated. A pendulum of this construction has been used with success at the Helsingfors Observatory since 1866. *See* Astronomische Nachrichten, Vol. 62, No. 1482.

488. Clepshydral Escapement.
Prof. W. H. Miller, M.A., F.R.S.

By means of the fountain bottle of Berzelius, or Gay-Lussac's syphon washing bottle, or any similar contrivance, a current of water is directed into a capsule, from which it is transferred by a syphon to the mouth of an inverted syphon partly filled with fine sand, one leg being rather more than twice as long as the other. The upper end of the short leg is stopped with a cork, in which is inserted a short syphon about 0·29 inch (8^{mm}) in diameter. A compensated pendulum carrying near its upper end at a distance of 5·5 inches (140^{mm}) an inverted funnel about 0·63 inches (16^{mm}) long, 0·27 inches (7^{mm}) wide at its base, and about 0·04 inches (1^{mm}) at the upper end. The lower end of the upper syphon is supported at about 0·12 inch (3^{mm}) above the top of the funnel carried by the pendulum when at rest. A tube of about 0·08 inches (2^{mm}) in diameter, and 0·4 inches (10^{mm}) long, is supported with its upper end about 0·12 inches (3^{mm}) below the lower end of the funnel at rest.

The pendulum being made to vibrate through a small arc before reaching the upper syphon takes up a drop, and on arriving near its lowest point delivers a drop to be carried off. The time is thus measured without allowing the pendulum to come in contact with any solid body except the agate plane on which it is supported.

The drop given off by the lower tube at the end of every two seconds, may be used to record every alternate second of time by means of a timepiece having a very light pendulum timed in accordance with the pendulum the water clock.

No attempt has been made to exhibit the mechanism for counting the seconds.

488a. Model of Compensation Balance, applicable to watches and chronometers. (With a drawing.)
M. Winnerel, Paris.

488b. Model of Escapement, applicable to the model clock at the Paris Observatory. (With a drawing.)
M. Winnerel, Paris.

488c. Model of Escapement, with simplified suspension, applicable to clocks. (With a drawing.)
M. Winnerel, Paris.

488e. Two Movements for Chronometers, one eight days and one two days. *Victor Kullberg.*

489. Standing Pendulum Clock, in black wooden box with silvered dial. *Professor Buys-Ballot, Utrecht.*

This is one of the first clocks made after Huygen's principle (*i.e.*, provided with cycloidal pendulum). This peculiarity may be seen by opening the door.

490. Two Conical Pendulum Clocks, for determining short time intervals. *Professor Buys-Ballot, Utrecht.*

Each of these clocks is contained in a truncated wooden column covered by a circular brass plate, by lifting which the dial may be seen. The foremost part of the box can be removed to put the pendulum in motion, the spring being wound up. In this condition only one hand moves. By pressing on the button at the foremost part of the dial, the two other hands move until the finger is withdrawn. In this manner very short lapses of time can be measured. The instruments must be placed accurately horizontal. These two specimens were used by Moll and van Beelt on the heath near Amersfoort for determining the velocity of sound. They are constructed for the decimal division of time, and indicate the ten millionth part of a day (24 hours).

491a. Very curious Timepiece, designed by Mudge.
E. Dent and Co.

The escapement is a true remoutoire; two small pendulum springs are wound up at every beat of the scape wheel, and these give impulse to the balance. The balance is controlled by two pendulum springs, one above and the other beneath it; the first of these receives the action of the "compen- " sation curb," the second is for ordinary regulation. The action of the "compensation curb" is analogous to the ordinary regulation by curb pins, but the curb pins are advanced backwards or forwards along the spring by the operation of the compensation pieces, which, being constructed of brass melted upon steel, bend at every change of temperature. The whole timepiece has been designed and got up with a surprising degree of refinement.

492. Working Model of Chronometer Escapement, with two inch scape wheel. *Philip John Butler.*

493. Small Electric Pendulum. Striking seconds on a bell, and thus capable of being used for astronomical studies. *Antoine Joseph Gérard, Liége.*

494. Book containing plans of instruments, apparatus, and machines. *Antoine Joseph Gérard, Liége.*

499a. Chronometrical Regulator, for putting in motion a registering cylinder. *Mr. Yvon Villarceau.*

This system of regulator, the theory of which is due to Mr. Yvon Villarceau, is represented by the model included among the objects exhibited by M. L. Breguet.

500. Edelmann's Seconds Pendulum, with galvanic attachment. *M. Th. Edelmann, Munich.*

501. Chronometric Comparateur, an instrument of coincidences, for determining the difference of time between two distant clocks. *M. Redier.*

501a. Collection of Steel and Electro-gilded Pendulum Springs. *E. Dent and Co.*

502. Clock employed in the Pantheon Experiment by M. L. Foucault. *Conservatoire des Arts et Métiers, Paris.*

502a. Different applications of Metal Tubes of elliptical section to instruments for measuring pressure, temperature, weight, speed, and time.

1. Manometer for steam, air, or water pressure.
2. Barometer. Counterpoised barometer.
3. Thermometer.
4. Tacheometer, or speed indicator.
5. Balance for light and heavy weights.
6. Clock with pneumatic motor.

M. Eugene Bourdon, Paris.

502a. Motor Clock and case, with two electric dials, batteries, and fittings. *T. Cooke & Sons.*

503. Electric Apparatus by M. Foucault, for keeping up continuously the motion of the clock. *Conservatoire des Arts et Métiers, Paris.*

503a. Marine Chronometers for ships' use. Manufactured by Victor Kullberg, Liverpool Road, London, N.
South Kensington Museum.

503b. Two-day Chronometer, fitted complete. Two movements reversed, to show the compensation balances.
South Kensington Museum.

503d. Chronometer and case on stand with glass shade.
The Royal Observatory, Greenwich.

509. Marine Chronometer, regulated at sidereal time, used by the Scientific Commission of Noumea in observing the transit of Venus. *Messrs. Tondola and Co., Paris.*

510. Marine Chronometer, suitable for distributing the hour in quarter minutes to an unlimited number of electric receivers, going for one year without being wound up. (System applied for more than three years with complete success.)
Messrs. Tondola and Co., Paris.

511. Marine Chronometer, regulated to mean time. Specimen of ordinary construction. *Messrs. Tondola and Co., Paris.*

512. Geographical Clock, with revolving planisphere; showing the time, longitude, and latitude, of all parts of the globe.
Messrs. Tondola and Co., Paris.

513. Astronomical Pendulum Clock.
W. Bröcking, Hamburg.

514. Wheel-work of Clock. *W. Bröcking, Hamburg.*

515. Astronomical Pendulum Clock with mercury compensation pendulum. *Th. Knoblich, Hamburg.*

517. Chronometer-escapement, model.
Th. Knoblich, Hamburg.

518. Anchor-escapement, model.
Th. Knoblich, Hamburg.

519. Pendulum Clock belonging to the tide-gauge of Mr. Reitz. *Th. Knoblich, Hamburg.*

519a. Clock worked by Water-power. *T. Hankey.*

520. Astronomical Pendulum Clock.
F. Dencker, Hamburg.

The Jürgens compensation pendulum system has an isochronous suspension spring, determined by calculation. It is, contrary to the formerly constructed repose pendulum, executed with sufficient stability. Not only is the expansion coefficient of the separate bars exactly determined by the pyrometer, but likewise the whole pendulum is directly controlled in the pyrometer. The pyrometer employed is of quite a novel construction; the observation takes place in a liquid, *without contact*, under two micrometer microscopes. As the observation through the microscope requires water of perfectly equable temperature, the uniformity of its temperature is ensured; the bars likewise must be quite homogeneous, as otherwise a bending of them will take place by a change of the temperature, whereby the terminal ends will move out of the range of vision. With regard to compound pendulums, the centre of gravity is to be found by means of a balance the point of flexion of the spring of which is known to the exhibitor, and then the point of oscillation by calculation; in a quite homogeneous and uniformly strong spring it is exactly in the centre. By means of a bar, which is adjusted exactly to the length of the pendulum,* the point of oscillation can be exactly fixed in the pyrometer, and the whole pendulum examined with regard to extension and stability. The working of the clock affords a check upon the accuracy of the measurement; if no error be made, the pendulum thus adjusted and fitted to a clock will exactly vibrate seconds.

521. Model Escapement. *F. Dencker, Hamburg.*

An anchor escapement, enlarged tenfold, with an impulse derived from the chronometer and acting like the same from fork upon balance. This requires no oil. The straight lines of the fork and the release stone render a quite exact execution possible, and consequently an effect which almost equals the direct impulse from wheel upon balance, without detracting from the great insensibility of the anchor escapement. The lifting which it is desired to give to the balance in this case is determined only by the length of the fork, independent of the length of the lever. Arranged for quarter seconds, it will be very useful for determining the time on journeys and on sea. The last seconds are regulated by a curb, permitting only little motion, but being securely guided by means of a screw. The last regulation by the balance screws always disturbs the equilibrium of the balance, and effects thereby a doubling of the errors at the change of the position. The flat spiral spring has an inner and an external curve.

522. Gold Watch. *F. Dencker, Hamburg.*

The pocket watch has been executed exactly according to this model in the exhibitor's establishment at Geneva. It is provided with a flat spiral spring hardened in fire according to his invention. Up to the present time no flat spiral springs hardened in fire are employed, as far as the exhibitor knows.

523. Watch with spindle without spiral spring; constructed in the East in the first half of last century, indicating month, day, and hour in Arabic figures. (Remarkable for its age and origin.) Property of H.H. Prince Pless, Fürstenstein.

The Breslau Committee.

523a. Watch, thickness of a crown piece, made for the late Sir C. Wheatstone by Mr. A. Stroh.

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* The extension of the parts to be employed being known, a pendulum can be determined by calculations which swings in exactly one second.

SECTION 4.—KINEMATICS, STATICS, AND DYNAMICS.

WEST GALLERY, GROUND FLOOR, ROOM K.

I. SPECIAL COLLECTIONS.

COLLECTION OF APPARATUS USED BY 'SGRAVESANDE TO ILLUSTRATE HIS PHYSICAL RESEARCHES.

524. 'sGravesande's Apparatus to demonstrate the **Laws of Centrifugal Force.**

Professor Dr. P. L. Rijke, Leyden.

(*See* 'sGravesande's "Physices Elementa Mathematica," 3rd edition, Vol. I., p. 153.)

525. 'sGravesande's Apparatus to demonstrate the **Theory** of the **Wedge.**

Professor Dr. P. L. Rijke, Leyden.

526. 'sGravesande's Apparatus, to show, by means of a pendulum furnished with weights and springs, that the same quantity of **Mechanical Work** produces the same quantity of **Vis Viva.**

Professor Dr. P. L. Rijke, Leyden.

527. 'sGravesande's Apparatus to demonstrate the **Laws** of **Falling Bodies.**

Professor Dr. P. L. Rijke, Leyden.

528. 'sGravesande's Apparatus for **Parabolic Motion.**

Professor Dr. P. L. Rijke, Leyden.

COLLECTION OF KINEMATIC MODELS, EXHIBITED BY THE KÖNIGL. GEWERBE-AKADEMIE, BERLIN, PROF. REULEAUX, DIRECTOR.

The models in this collection are connected throughout with Professor Reuleaux's treatment of the theory of machines. Their nature will be found fully discussed in his "*Theoretische Kinematik*" (Vieweg und Sohn). The English edition of this work (Macmillan), translated and edited by Professor Alexander B. W. Kennedy, C.E., of University College, London, was published in June. The English names of the mechanisms here given are those used by Professor Kennedy in his translation.

551. I.—Pairs of Kinematic Elements.

(*a.*) LOWER PAIRS.

1. Turning or cylinder pair, $R^{+}_{=}\ R^{-}$ or $C^{+}_{=}\ C^{-}$.
2. Sliding or prism pair, $P^{+}_{=}\ P^{-}$.
3. Twisting or screw pair, $S^{+}_{=}\ S^{-}$.

552. Pairs of Kinematic Elements.

(*b.*) HIGHER PAIRS.

4. Equilateral duangle in equil. triangle.

   These models of the higher pairs of elements can be inverted; that is, the movable element can be fixed, and the fixed element made movable. The centroids are shown in thick black or red lines; the roulettes, or point-paths, in thinner lines.

5. Expanded duangle in equil. triangle.
6. Equilateral curve-triangle in square.
7. Equilateral curve-triangle in rhombus.
8. Expanded isosceles curve-triangle (90°) in square.
9. Expanded equilateral curve-triangle (90°) in rhombus.
10. Regular curve-pentagon in square.
11. Symmetrical curve-pentagon in square.

553. II.—Conic Axoids, with corresponding Spheric Roulettes and Profiles.

12. Spheric epicycloid.

    Ratio 1:3.

13. Spheric cycloid.

    A full cone rolling upon a plane cone (1:3).

14. Spheric hypocycloid.

    A full cone rolling in an open one (2:1).

15. Spheric hypocycloid.

    Ratio 1:3.

16. Spheric pericycloid.

    The curve upon the rolling cone passes always through the describing point of the fixed one.

17. Spheric involute.
    Ratio 1:3.
18. Spheric involute.
    Ratio 8:9 ; the curve in red is a curtate involute.
19. Apparatus for describing spheric cycloids.
    Describes, among other curves, those here exhibited.

554. III.—Simple Kinematic Chains and Mechanisms.

20. Quadric cylindric-crank chain.
21. Slider-crank chain.
22. Quadric conic-crank chain.
23. Reduced slider-crank chain.
    The link *c* omitted.
24. Reduced slider-crank chain.
    Links *a* and *c* omitted.
25. Reduced conic-crank chain.
    The link *c* omitted.
26. Quadric crank chain with slot and sector.
27. Single crossed slide chain.
28. Double crossed slide chain.
29. Simple spur-wheel chain.
30. Simple spur-wheel chain with annular wheel.
31. Endless screw.
32. Stand for carrying the above models when in use.

555. IV.—Crank Trains.

33. Double slider-crank.
34. Slider-crank.
    With centroids.
35. Slider-crank.
    With centroids.
36. Double slider-crank.
    With centroids. (The centroids are here Cardan's circles.)
37. Slider-crank.
38. Skew double slider-crank.
39. Double slider-crank with curved slide.
40. Double slider-crank with skew slide.
41. Lever-crank.
42. Double slider-crank with curved slide.
    With pin expansion.
43. Slider-crank.
    Link *b* is here a disc.
44. Slider-crank.
    With adjustable connecting rod.
45. Slider-crank.
    With adjustable cross-head.

46. Slider-crank.
    In the form of a marine engine.
47. Slider-crank.
    Slotted link gear.
48. Slider-crank.
    Double slide gear.
49. Slider-crank (Norman Wheeler).
    Three-fold.
50. Slider-crank, with pin expansion, 2 within 1.
51. Slider-crank, with pin expansion, 1 within 2.
52. Slider-crank, with pin expansion, 3 within 2.
53. Slider-crank, with pin expansion, 2 within 3.
54. Slider-crank, with pin expansion, 2 within 3.
    Annular expansion.
55. Slider-crank, with pin expansion, 1 within 2 within 3.
56. Slider-crank, with pin expansion, 3 within 2 within 1.
57. Slider-crank, with pin expansion.
    Adjustable stroke.
58. Swinging block (slider-crank).
59. Turning block (slider-crank).
60. Skew (turning) cross block.
61. Turning block (slider-crank).
    With pin expansion (can be used also as a turning slider-crank).
62. Turning block (slider-crank).
    With reduced centroids.
63. Double crank (drag-link coupling).
    With reduced centroids.
64. Turning block (slider-crank), Redtenbacher's "Maskirte Kurbelschleife."
    Quick return motion; the stroke is adjustable.
65. Swinging slider-crank.
65*a*. Swinging double slider.
66. Swinging skew double slider.
67. Conic crank-train.
68. Isosceles double-crank (Galloway).
    Mean velocity, ratio 1 : 2.
69. Isosceles double-crank (Galloway).
    Mean velocity, ratio 1 : 2; arrangement for crossing dead points, by Reuleaux.
70. Anti-parallel cranks (Reuleaux).
    Special arrangement for crossing dead points.
71. Anti-parallel cranks (Reuleaux).
    With centroids, which are ellipses.
72. Anti-parallel cranks (Reuleaux).
    With centroids, which are ellipses and hyperbolæ.

73. Double parallel crank train, used as a coupling.
For transmitting uniform rotation.

74. Double parallel crank train, used as a coupling (Reuleaux).
For transmitting uniform rotation.

75. Crank train for transmitting uniform rotation (Heilmann).
76. Crank train for transmitting uniform rotation (Böhm).
77. Differential crank train (Römer).
Numbers of teeth, 56 and 56, with apparatus for tracing diagrams.

78. Differential crank train (Römer).
Numbers of teeth, 56 and 57, with apparatus for tracing diagrams.

79. Differential crank train (Römer).
Numbers of teeth, 30 and 90, with apparatus for tracing diagrams.

80. Hooke's joint.
81. Universal joint (Blees).
82. Universal joint (Polhem).
83. Universal joint (Reuleaux).
84. Universal joint (Klein).
85. Universal joint (Klein).
Simplified by Reuleaux.

86. Double Hooke's joint.
The velocity ratio here can be made constant.

556. IV*a*.—Mechanisms for describing Straight Lines (exactly or approximately).

87. Roberts triangle, "parallel motion."
88. Triangle motion, inverted, by Reuleaux.
89. Elliptic linkwork (Nehrlich), 3rd form, inverted.
90. Elliptic linkwork (Nehrlich), 3rd form, inverted.
91. Hypocycloidal linkwork.
92. Hypocycloidal linkwork, inverted, by Reuleaux.
93. Epicycloidal linkwork, Reuleaux.
94. Elliptic linkwork, inverted.
With the whole motion.

95. Tchebischeff's linkwork.
Arranged so that it can be inverted.

96. Conchoidal linkwork, 1st form.
97. Conchoidal linkwork, 3rd form (Reichenbach).
98. Conchoidal linkwork, 3rd form (Reuleaux).
99. Lemniscoidal linkwork, 1st form (Watt).
100. Lemniscoidal linkwork, 2nd and 3rd forms.
101. Lemniscoidal linkwork, 1st form, inverted (Reuleaux).
102. Lemniscoidal linkwork, 2nd and 3rd forms.
Steam engine model with Watt's planet wheels.

103. Sector mechanism (Reuleaux).
Involute.

104. Sector mechanism (Reuleaux).
Cycloid.

105. Sector mechanism (Reuleaux).
Cycloid.

106. Cartwright's mechanism.
107. Maudsley's mechanism.
108. Tchebischeff's mechanism.
109. Harvey's mechanism.
110. Harvey's mechanism.
111. Pantograph.
With elliptic linkwork, 1st form.

112. Pantograph.
With prism guide.

113. Semi-pantograph.
With prism guide.

114. Semi-pantograph.
Steam engine model.

115. Rhombic linkwork.

557. V.—Apparatus for describing Curves.

116. Ellipsograph.
117. Ellipsograph, by Slaby, on Haman and Hempel's system.
Describes also cycloids. Dr. Slaby's construction contains very essential improvements.

118. Elliptic chuck (Leonardo da Vinci).
119. Elliptic chuck (Delnest).
120. Sinoid and cardioid tracing gear.
121. Curve tracing apparatus.
122. Curve tracing apparatus.
123. Mechanism for describing Lissajous' figures.
Describes also ellipses.

124. Hastie's conoid gear.
125. Tricentric gear.
For the construction of three-grooved taps, &c.

126. (Form-) copying machine.
127. Rose-engine.
128. Rose-engine.
129. Rose-engine.
130. Rose-engine, special form.

558. VI.—Parallel or Translating Trains.

131. Parallel ruler.
Single and double.

132. Parallel ruler.
With crossed bars.

133. Complete lever parallel train.
Weighing machine, of Roberval.

134. Incomplete lever parallel train.
Weighing machine, of Milward.

135. Incomplete lever parallel train.
Weighing machine, of Farcot.

136. Incomplete lever parallel train.
Weighing machine, of Schwilgué.

559. VII.—Compound Parallel Trains.

137. Feathering paddle-wheel, of Buchanan.
A combination of trains similar to parallel rulers. The floats remain always vertical.

138. Feathering paddle-wheel, of Oldham.
The floats rotate about their axes as the wheel revolves.

139. Feathering paddle-wheel, of Morgan.
With eccentric ring.

560. VIII.—Higher Couplings.

140. Uhlhorn's coupling.
141. Oldham's coupling.
142. Reuleaux's grooved disc coupling.
143. Köchlin's cylindric coupling.
144. Schürmann's cylindric coupling.
145. Conic coupling.
146. Pouyer-Quertier's coupling.

561. IX.—Toothed-wheel Trains.

147. Spur wheels (point-paths used for profiles).
148. Returning spur-wheel train.
149. Returning spur-wheel train, with annular wheel.
150. Returning spur-wheel train, with annular wheel.
151. Returning spur-wheel train, with two annular wheels.
152. Returning spur-wheel train, with two annular wheels.
153. Returning spur-wheel train, with intermediate wheel.
154. Returning spur-wheel train, with intermediate wheel.
Reuleaux's so-called halving spur-wheel train.

155. Returning spur-wheel train.
With Marlborough wheel.

156. Spur-wheel train.
The centroids are Cardan's circles.

157. Beylich's universal wheels.
" Pin-wheels."

158. Cylindric friction wheels.
Held by axial pressure.

159. Screw wheels.
    Working as spur-wheels.

160. Screw wheels.
    Screw wheel and rack.

161. Bevel wheels.
    Plane- (face-) wheel and full wheel.

162. Mangle-wheel train.
    Automatic reversal.

163. Mangle-wheel train.
164. Mangle-wheel train.
    With internal teeth.

165. Whitworth's feeding gear for drills.
    The drill is under a constant pressure.

166. Reversing gear, claw coupling.
    With bevel wheels.

167. Reversing gear, bevel wheels.
168. Reversing gear, returning wheel gear.
    By Reuleaux.

169. Reversing gear, Sellers' arrangement.
    Open and crossed belts.

170. Reversing gear, with three pulleys.
171. Face-wheel and runner (Rupp).
172. Speed changing gear (Sellers).
    For lathes.

173. Speed changing gear with double pulleys.
174. Reversing and disengaging train (radial).
    Wheels of 103 and 53 teeth respectively.

175. Reversing and disengaging train (Fairbairn's).
176. Reversing and disengaging train (Brown's).
177. Engaging and disengaging train (Platt's).
178. Engaging and disengaging train (Curtis').

Globoid Gearing.

179. Globoid screw wheels ; spheric screw and wheel.
    Reuleaux.

180. Globoid ring, screw, and wheel.
    Reuleaux.

181. Skew globoid ring, conic screw and tooth.
    Reuleaux.

182. Globoid ring, cone, and wheel.
    Used by Stephenson in locomotive reversing gear.

183. Crossed globoid ring, screw, and tooth.
    Reuleaux.

184. Crossed globoid ring, screw, and tooth.
    Reuleaux.

185. Globoid screw and screw wheel.
Endless screw.

186. Globoid screw.
Applied in horse gins; velocity ratio 1:12.

Parallel Wheels.

187. Parallel wheels with 24 teeth.
Reuleaux. The teeth are revolutes.

188. Parallel wheels with 6 teeth.
Reuleaux. Would work also with 3 teeth. The teeth are pins.

189. Parallel wheels with 5 teeth.
Reuleaux. One wheel annular.

190. Parallel wheels with 24 (pin) teeth.
Reuleaux. The parallelism is destroyed by displacing the axes.

Planet Wheel Chains.

191. Planet wheel chain.
192. Planet wheel chain, $a=b=\infty$.
With excanching wheels.

193. Planet wheel chain, $a=b=\infty$.
194. Planet wheel chain, with annular wheel.
195. Planet wheel chain, $b=c=\infty$.
196. Hyperboloidal endless screw.

562. X.—Belt-trains.

197. Returning belt-train.
Shows the alteration of velocity due to the slipping of the belt.

198. Skew belt-train.
Acts in one direction only.

199. Belt-train with crossed guide pullies.
The necessary tension is given to the belt at the instant it is thrown into gear.

563. XI.—Slider-cam Trains.

200. Sinoidic cams. Cardioids.
Open cam with roller, pair-closure.

201. Sinoidic cams. Cardioids.
With second disc and centroid.

202. Sinoidic cams. Cardioids.
Pair-closure.

203. Sinoidic cams. Polar sinoid.
With centroid.

204. Sinoidic cams. Polar sinoid.
With centroid.

205. Cams with discontinuous profiles. Curve-triangle in skew curved slot.
With centroid.

206. Cams with discontinuous profiles. Equilateral curve-quadrangle.
With centroid.

207. Cams with discontinuous profiles. Equilateral curve-pentagon in straight slot.

208. Cams with discontinuous profiles. Equilateral curve-pentagon in adjustable slot.
Both parts are adjustable.

209. Cams with discontinuous profiles. Curved disc in curved slot.
Both parts are adjustable.

210. Cams with discontinuous profiles. Curved disc.
For the motion of a slide valve.

211. Cams with discontinuous profiles. Disc with looped slot.
With shuttle, used in printing presses.

212. Slider-cam, two-lobed cylindric sinoid.
Force-closure.

213. Slider-cam.
Force-closure.

214. Slider-cam, cylindric sinoid.
215. Screw reversing train of Whitworth.
216. Steering gear of Scott and Sinclair.
217. Steering gear of Steel (Greenock).
218. Steering gear of McWilliam.
219. Steering gear of Reed.
220. Steering gear of Rogers.
221. Steering gear of Reuleaux.
222. Boring machine.
223. Boring machine (Stehelin).
224. Boring machine (Reuleaux).
225. Differential screws.
226. Differential screws, with wheel train.
227. Double screw train (Napier).
Self-acting return.

228. Cam reversing train (Girard).
For governors.

229. Leading screw with disengaging gear.
With self-acting disengagement.

230. Screw disengagement (Whitworth).
With pallet action.

231. Screw heckling machine (Houldsworth).

564. XII.—Ratchet Trains.

232. Click train.
With two external and one internal clicks.

233. Centrifugal click train.
If rapid rotation occur, the centrifugal force throws out the click.

234. Silent click train.
235. Pinching click train.
236. Click train of Wilbers.
237. Ratchet train of Langen.
Used in gas engines.

238. Turning ratchet gear (Maltese cross wheel).
239. Turning ratchet gear (incomplete cross wheel).
240. Turning ratchet gear (spur wheel).
241. Ratchet train.
With automatic disengagement.

242. Ratchet train, with pin teeth.
With automatic disengagement.

243. Ratchet train (Reed).
With automatic disengagement and fall.

244. Ratchet train, with fast click.
245. Single acting ratchet train.
The direction of motion can be altered.

246. Double acting ratchet train.
247. Reversing ratchet train (Francis).
Used for governors.

248. Dividing machine (Nasmyth).
249. Lagarousse ratchet gear.
With eccentric.

250. Crown wheel ratchet train.
251. Tooth ratchet train, with double acting free click.
Model illustrating action of a force pump.

252. Escapement train (Mudge).
Can be held in the stand, No. 32.

253. Throttle click train.
Illustrates the action of the throttle valve.

254. Ratchet train, with pinching clicks.
255. Ratchet train, with several clicks.
256. Ratchet train, with free clicks.
Directing gear can be added so as to illustrate the action of steam engine.

257. Ratchet train, with fast clicks.
258. Ratchet train, with Farey's director.
259. Ratchet train, with Watt's director.
Watt's automatic valve gear.

260. Double acting ratchet gear.

261. Ratchet train, with cataract director (Hoffmann).

262. Double acting ratchet gear.
(Reuleaux.) Shows that the steam engine is a ratchet train. The model can be worked with various forms of directing gear; it stands upon a large mahogany frame with columns.

263. Apparatus for using with Nos. 244 to 254 :—Column with fly wheel and two connecting rods.

Escapements.

264. Graham's anchor escapement.

265. Escapement of Reuleaux.

266. Pin escapement of Lepaute.

267. Escapement of Denison.
With three-toothed escape wheel.

268. Gravity escapement of Denison (1860).
As in the clock at the Houses of Parliament.

269. Gravity escapement of Denison.

270. Spindle escapement.

271. Cylinder escapement.

272. Anchor escapement.

273. Chronometer escapement of Jürgensen.

564a. XIII.—Chamber-crank Gears and Chamber-wheel Trains.

274. Chamber-crank gear, Simpson and Shipton.
Steam engine.

275. Chamber-crank gear, Bährens, Napier, Bompard.
Steam engine.

276. Chamber-crank gear, Wedding, Cochrane.
Ventilator.

277. Chamber-crank gear, Ramelli.
Pump.

278. Chamber-crank gear, Beale.
Gas exhauster.

279. Chamber-crank gear, Cochrane.
Steam engine.

280. Chamber-crank gear, Pattinson.
Pump.

281. Chamber-crank gear, Minari, Stocker.
Steam engine and pump.

282. Chamber-crank gear, Ramey.
Steam engine and pump, with elliptic wheels.

283. Chamber-crank gear, Lemielle.
Ventilator.

284. Chamber-crank gear, Cochrane.
Steam engine.

285. Conic crank gear, Davies.
Steam engine.

286. Parallel crank gear, Galloway.
Steam engine.

287. Chamber-wheel train, Pappenheim.
Pump.

288. Chamber-wheel train, Fabry.
Ventilator for mines.

289. Chamber-wheel train, Fabry.
290. Chamber-wheel train, Root.
Blower.

291. Chamber-wheel train, Root.
Blower.

292. Chamber-wheel train, Payton.
Water-meter.

293. Chamber-wheel train, Evrard.
Pump.

294. Chamber-wheel train, Repsold, Lecocq.
Pump.

295. Chamber-wheel train, Dart, Behrens.
Pump.

296. Chamber-wheel train, Ganahl, Eve.
297. Chamber-wheel train, with three wheels.
298. Screw-wheel chamber train, Révillion.
Ventilator.

564b. Kinematic Compasses with Three Branches, designed by Reuleaux.

Royal Academy of Industry, Berlin, Director, Prof. F. Reuleaux.

By means of this instrument it is easy when the orbs of two points of a system are given, to find all the other curves of the same system.

(See Reuleaux's "Kinematik," s. 24, and following.)

The third branch of these compasses may be altered longitudinally, and is, besides, provided with a joint, so that entirely obtuse angular triangles (amblygons) as well as entirely acute-angled triangles (oxygons) can be taken by the compasses, for which the three-branched compasses of older construction were not adopted.

These compasses were manufactured by J. Kern, mechanical instrument maker, at Aarau, Switzerland, by order of the exhibitor.

II. ELEMENTARY ILLUSTRATIONS.

528a. Parallelogram of Forces.

Dr. G. Krebs, Frankfort-on-the-Maine.

528b. Inclined Plane.

Dr. G. Krebs, Frankfort-on-the-Maine.

528c. Inclined Plane, constructed by Professor Dr. Bertram, Councillor of the Board of Education. *Ferdinand Ernecke, Berlin.*

The inclined plane is represented by two parallel iron rods, which can be placed at any angle with the horizontal bar.

Three distances can be measured as follows :—

1. The length of the inclined plane, that is to say, the distance from the joint to the perpendicular iron support bar, which maintains the plane in its proper position.

2. The base, that is to say, the horizontal distance from the joint to the support bar ; this is read on the horizontal pedestal.

3. The height, that is to say, the perpendicular from the terminal point of the first distance to a horizontal line drawn through the joint ; this is read on the support bar, the zero point of which is situated on a level with the joint.

The weight on the inclined plane can be balanced in two different ways : either parallel to the inclined plane, or in a horizontal direction. The carriage of the roller can be turned, and the pulling string can, therefore, be placed parallel to the inclined planes or horizontally. The double division on the slotted support bar serves for observing the horizontal position of the string.

At every experiment the weight carriage, that is, the two-wheeled axle with its scale, is balanced with the scale which is suspended on the string. This is effected by tare weights. Then the weight and the power of traction, that is to say, the weights which are balancing each other in the weight scale and the traction scale, are adjusted by means of the measured distances.

1. If the string remains parallel to the inclined plane, then the weight is to the traction in the proportion of the length of the inclined plane to the height.

For example, if the length be 80 and the height 40, then 20 grammes in the weight scale will be balanced by 10 grammes in the traction scale.

2. If the string remains horizontal, then the weight is to the traction in the proportion of the base of the inclined plane to the height.

For example, if the base be 40 and the height 40, then 4 grammes in the weight scale will be balanced by 20 grammes in the traction scale.

In order to make the difference in the two cases intelligible, such positions in the inclined plane are advantageous in which the three distances are indicated by round numbers, such as height, 20 ; length, 29 ; base, 21. The weight 20 in the traction scale balances with the string in a horizontal position, the weight 21 ; and with the string parallel the weight 29 will be balanced. With the height 30 and the base 40 the length will be 50, and 30 grammes in the traction scale will balance 50 grammes in the weight scale with a parallel direction, whilst the weight required in a horizontal direction will amount to 40 grammes.

528d. Parallelogram of Forces, constructed by Professor Bertram. *Ferdinand Ernecke, Berlin.*

Apparatus for demonstrating the theorem of the parallelogram of forces.

If two adjacent sides of a parallelogram represent in magnitude and direction two forces acting at a point, the diagonal through the point will represent their resultant in magnitude and direction.

This theorem is illustrated by the apparatus. The angular point of the parallelogram is the (white) peg, over which a ring has been placed, on which are fastened the three cords ; the magnitude of the forces is determined by the weights in the pans, the directions pass along the three rails of which the one, AB, which is fixed, vertically ; the second AC, and the third, AE, movable around the peg A, always move in the diagonal of the parallelogram BADF, produced. The greatest of the forces is always taken in the direction of AB, and determined as equal to 100, and the value of the two others is read on the graduations of the lines BG and AF.

If, for example, the parallelogram is placed so that the lines are respectively AB=100, BF=70, AF=80, the ring in that case will poise freely without coming into contact with the peg, if the weights in the pans amount respectively to 100, 70, 80 grammes; the weights of the pans, of course, must be adjusted previously by tare weights.

528e. Centrifugal Apparatus, complete.
Ferdinand Ernecke, Berlin.

529. Drawing. Experimental demonstration of the theory of the parallelogram of forces and velocities, used by the exhibitor since 1835. *Professor Daniel Colladon, Geneva.*

Two small pulleys are placed at some distance from each other on the edge of a table. On the opposite edge, held by the hand, is a small ball of the size of a musket ball, to which are attached, by one of their extremities, two helical springs of fine brass wire; the other extremity of these two springs is drawn parallel to the plane of the table by cords passing over the pulleys, and themselves stretched by the weights P and P′. The table being sprinkled with sand or seeds, two lines are traced upon it, marking in direction and intensity the tensions of the two springs which draw the ball, which are equal to the weights P and P′. On discharging the ball it traces on the table a straight line, which is in the direction of the diagonal of the parallelogram of the forces P and P′ of the two springs.

III. PRINCIPLES OF MECHANISM.

529a. Models (14) of the various **Linkworks** for effecting the exact rectilinear motion of a point, commonly known as "parallel motions." *A. B. Kempe, B.A.*

Selected from a number described by the exhibitor in a paper published in the "Proceedings of the Royal Society," No. 163, 1875, and entitled, "On "a General Method of producing exact Rectilinear Motion by Linkwork," which points out the common principle on which the linkworks depend.

The points which have rectilinear motion are denoted by stars.

529b. The Sylvester-Kempe Parallel-Motion. Model of a linkwork for effecting the exact rectilinear motion of a point.
A. B. Kempe, B.A.

Discovered simultaneously by Professor Sylvester and the exhibitor in 1875. The main portion of the apparatus consists of a linkwork of four bent rods called a "Quadruplane," which is such that four points, one on each rod, always lie at the angles of a parallelogram of constant area and angles. Two of the points consequently are situate at such distances from a third that the one distance is the inverse of the other. One of the points being fixed, another is made by means of a link to move in a circle passing through the fixed point, the other then describes a straight line. If the bent rods are made straight, the four points lie in a straight line, and the parallel motion becomes that of Mr. Hart.

529d. Model of a Linkwork, by which two rods may be made to rotate about the same axle with equal velocities in contrary directions. *A. B. Kempe, B.A.*

This and the following linkwork are described by the exhibitor in the "Messenger of Mathematics," No. 44, 1874.

529e. Model of a Linkwork, by which rods may be made to rotate about the same axis with velocities proportional to 1, 2, 3, &c. The linkwork can also be used to divide angles into a number of equal parts. *A. B. Kempe, B.A.*

529g. Model of a Parallel Ruler. *A. B. Kempe, B.A.*

In this ruler the upper bar is constrained to move vertically up and down, and has no lateral motion.

529i. Link Motion. *William Howe, Chesterfield.*

The sketch was made by W. Howe, in August 1842, which was the first sketch of the shifting link motion. The small rough wooden model was begun by William Howe, in or about 1838, at the Vulcan Foundry, near Warrington, Lancashire, where the sectional cylinder, piston, valve, and foundation frame were made, but this was not for the purpose of applying the link motion, but a tappet motion. When the sketch referred to above was made, the link motion was applied to that model, and all the parts of the old model that could be brought in were used. The model of the twin bar link was designed in 1848 by William Howe, and made by Mr. William Usher, who was on a visit to William Howe at the time.

529j. Model of Mechanism invented by a pupil of the Royal School of Mines of Madrid, Dr. Horacio Bentabol, to ascertain the direct line of a given point by means of linkage.
Royal School of Mines, Madrid.

A memoir by the author accompanies this model, in which all the necessary details are given.

76c. Instrument, with joint, which makes its upper part movable in a horizontal plane.
Professor Tchebichef, University of St. Petersburg.

76d. Model of joint, which directly transforms a reciprocating into a circular motion.
Professor Tchebichef, University of St. Petersburg.

530. Drawing and Model of a connecting motion between two shafts turning in reverse directions. *Charles Bourdon.*

530a. Four Models, for the description of tooth-profiles, and lines of contact.
Royal Rhenish Westphalian Polytechnic School, Aix-la-Chapelle.

No. 1 illustrates the construction of *general* toothing, according to Reuleaux's method.

No. 2 shows that by the describing point of a string which runs over two rollers, two evolutes constantly coming in contact are traced relatively to them, which for this reason are tooth-profiles correctly working together.

As the same profiles are described when the axes are removed from or brought nearer to each other, it follows that evolute-wheels may alter the distance of their axes, preserving, notwithstanding, correct contact.

The circles " K " and " K_1 " cut off from the "*contact line*" *a b*, the *contact space* PP.

No. 3 shows that at the *cycloid toothing*, the " *contact space* " consists of the curves (segments) cut off from the head circles, and that every normal placed on the tooth-profile in the common point of contact of two teeth always passes through the point of contact of the two dividing circles.

No. 4 evolves spontaneously the circumferential line of the smallest possible space between the profiles.

530b. Model of Weston's Differential Pulley, with weights complete.
Polytechnic School at Halle, Director Kohlmann.

IV. PENDULUMS AND GYROSCOPES.

531. Gyroscope. A mechanical contrivance to exhibit the phenomena of rotation, and to show experiments on the deviation of spherical projectiles. *Elliott Brothers.*

532. Foucault's Gyroscope. Ordinary model.
Geneva Association for the Construction of Scientific Instruments.

532a. Gyroscope, by Foucault. *College of France, Paris.*

532c. Electric Gyroscopes. *G. Trouvé, Paris.*

Illustrating trials concerning the maintenance by means of electricity of the motion of the " Foucault " gyroscope. (Solution of the problem of gyroscopy, laid before the inventor by M. Foucault in 1864.)

533. Polytrope. A gyroscope mounted on circles so as to prove the laws of combined rotations about several axes. It may be used to determine the *meridian* or the *latitude* of a place, and to show the rotation of the earth on its axis, and for other experiments. *The Council of King's College, London.*

534. " Soldier Experiment." Model designed to demonstrate the relative effects of revolution and of rotation, separate or combined, by the movements of soldiers. *Henry Perigal.*

535. Compass Experiment, demonstrating that a magnetised needle does, but an unmagnetised needle does not, maintain its parallelism while revolving in a circle. *Henry Perigal.*

536. Gyroscope, demonstrating the effects of revolution and of rotation, the two ways of turning round. *Henry Perigal.*

537. Gyroscope, demonstrating that revolution alone will account for our always seeing the same face of the moon. *Henry Perigal.*

538. Selenoscope, to demonstrate the kinematic effects of the three hypotheses of the moon's motion, as a satellite of the earth. *Henry Perigal.*

539. Kinescopes, illustrating the laws of compound circular motion, by ocular demonstrations of their representative curves, shown by bright beads revolving with great rapidity. *Henry Perigal.*

539a. Pendulum Apparatus, for the graphic representation of the combination of rectangular and non-rectangular vibrations, with illustrative plates.

Institute for Physical Science of the University of Halle, Professor Knoblauch.

An apparatus for the graphical representation of two simultaneous oscillations inclined to each other.

To a table are fastened the bearings of two pendulums, the oscillation-planes of which are permitted to change their angle of inclination. One of these pendulums transmits its motion to a horizontal bridge, the other to a writing pen which moves exactly above the bridge. The oscillatory directions of the bridge and the writing pen are the directions of the combined velocities. The curve the pin traces on the oscillatory bridge is to be considered as the trajectory of a point moving on a plane at rest under the simultaneous oscillations of the pin and the bridge.

This trajectory is recorded either by the motion of a steel pin over a piece of sooted paper, or on white paper by a narrow-pointed glass tube filled with aniline ink.

If the weights on the pendulums are displaced the proportion of their oscillatory movements is altered; every difference of phase is obtained by an appropriate choice of the time, one pendulum beginning to move after the other. In this way the apparatus produces the greatest variety of geometrical figures.

The traces accompanying the apparatus may serve as specimens, which were drawn by the apparatus.

A more exact and scientific explanation is to be found in the "Zeitschrift "für die gesammten Naturwissenschaften von Dr. C. Giebel," Bd. XIV., October 1875.

The apparatus has been designed by P. Schœnemann in the Royal Seminary of Dr. Knoblauch, Professor of Physics at the University of Halle, and has been executed for the physical science cabinet of the University by Kleemann, mechanical engineer (Halle, Mauergasse 6).

539b. Compensation Pendulum. *Rohrbeck and Luhme, Berlin.*

539c. Tisley's Compound Pendulum Apparatus, for combining two rectangular harmonic vibrations producing figures known as Lissajous' curves. See Report of the British Association 1873; Engineering, Feb. 6, 1874; also "Sound," 2nd ed., Tyndall. *Tisley and Spiller.*

539d. Donkin's Harmonograph, for compounding two parallel harmonic motions. See Proceedings, Royal Society, 1874. *Tisley and Spiller.*

V. VIBRATIONS AND WAVES.

540. Apparatus for the Composition of two parallel simple vibrations.

Dr. F. G. Groneman, Groningen.

1. Principle. If the point C moves with constant velocity on the circumference of the circle HCG, it is known that its projection B upon the diameter GH performs a motion, which is called a simple vibration.

If to this variable point B a string is fixed, which is passed over the pulley D, and from this hangs down to E, so that BD + DE is the constant length of the string, it is easy to see that the point E will perform the same motion as B.

If this string is not attached to B, but to the moving point C itself, E will have a motion which is not strictly, but nearly that of B, the difference resulting from the difference of the two variable lines BD and CD. This difference can be diminished to any degree, by increasing the distance between the pulley and the centre A.

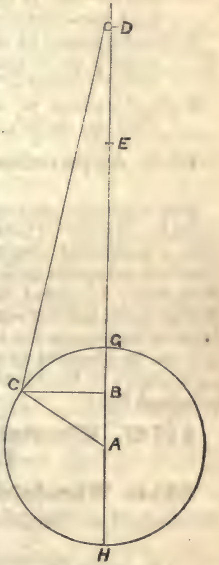

Fig. 1.

2. Two discs of the same diameter are placed in the same vertical plane, and can turn round horizontal axes, one of which has a handle. The motion of the first disc is communicated to the second by means of crown wheels and cog wheels. One of the latter can be fixed at any point of its axis, so that it may be made to gear with each of the six crown wheels of the second disc. By this arrangement the ratio of the velocity of the second disc to that of the first can be made successively equal to 1, $\frac{18}{17}$, $\frac{4}{3}$, $\frac{3}{2}$, $\frac{2}{1}$, $\frac{3}{1}$. For changing this velocity, or for changing the difference of the phases, when the velocities of the discs are the same, the washer at the end of the axis of the second disc must be a little loosened, and this axis pushed forward.

3. The discs have one knob each. If the distance of the knob of the first disc from the centre is called 1, that of the knob of the second disc can be made successively 1, $\frac{1}{2}$, or $\frac{1}{10}$. From the knobs proceed two strings, which pass through the pulleys on the top of the instrument, and are attached to the hooks A and B (Fig. 2).

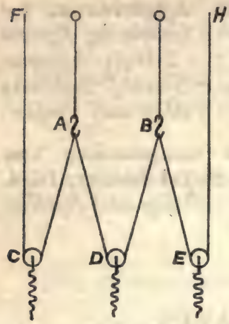

Fig. 2.

It is easy to understand that these hooks, when the handle is turned, perform two simple vibrations, the one being invariable, the other variable, in amplitude, phase, and velocity.

4. From A and B proceed two strings, passing through the pulleys C and E, and fixed in F and H. These pulleys have strictly the same motions as A and B, but reduced in the ratio one half. A third string proceeds from A to B, passing through D. At any moment the displacement of D will be the sum of the displacements of A and B, reduced one half. Its motion is therefore the resultant of the displacements of C and E.

The motions of the three pulleys are shown by the little white balls, placed on the front of the instrument.

5. With this apparatus an infinite number of combinations can be demonstrated, of which the following are examples :—

a. Two vibrations of the same amplitude and velocity, no difference of phase. The middle ball has double the amplitude.

b. The same, the difference of phase being 180°. The motion of the middle ball is nearly zero. The deviation that will appear results from the difference in the length of BD and CD (Fig. 1).

c. Combinations of a tone with one of its harmonics 2 and 3 with its quint $\frac{3}{2}$, or its quart $\frac{4}{3}$, as well as when they are of the same intensity or not (theory of the timbre).

d. Combinations of two tones of the same intensity, with the interval $\frac{18}{17}$, showing the origin of beats.

541. Apparatus, of a new form, to illustrate **Wave Motion.**

C. J. Woodward.

This apparatus consists of a series of balls suspended from a horizontal beam by strings. These balls rest against a series of partitions in a wedge-shaped horizontal trough, which can be raised and depressed parallel to itself. The box, being drawn on one side in the plane in which the balls hang and then slowly depressed, the balls will be successively liberated, and a wave, similar to that of the sound wave, produced. If the beam be drawn aside prior to depressing the box, the balls will rest against one side of the trough and can be liberated in succession, causing them to oscillate in a plane at right angles to the beam, a vibration being produced similar to that of plane polarized light.

1576f. Wheatstone Wave Machine.

The British Telegraph Manufactory, Limited.

541a. Wheatstone's Apparatus, for illustrating the composition of rectangular vibrations.

The Council of King's College, London.

542. Drawings of new Apparatus for demonstrating the composition of **Vibrations.** *Dr. Leopold Pfaundler, Innsbruck.*

Plate I. Two blackened glass discs are each placed on a separate horizontal axis one before the other, in such a manner that the transparent curves apparently cut in their periphery, intersect each other nearly at right angles. A reflection of light is produced thereby, which, at the revolution of the discs,

will generate figures such as are caused by the complex effect of the vibrations acting at right angles upon one another. By a simple mechanical contrivance the velocity of the rotary motion of each of the discs can be regulated according to equally simple relative relations, by which the figures of the different intervals are produced. By varying the tension of the strings more or less, an alteration in these places will be achieved. By changing one or the other of these discs, and replacing it by another with a different curve, the figures observed by Dr. Helmholtz, on oscillating strings with the vibration microscope, will be obtained, instead of those of Lissajous.

Plate II. Two thin rods of steel are fastened by screws at the two oblique corners of a strong bar of iron in such a manner that their further ends, one reaching above the other, vibrate vertically the one upon the other. To these ends small metal plates with incised slits are attached in a parallel position. The reflection of light produced by the intersection of these slits will show Lissajous' figures. A movable weight regulates the intervals.

B, the well known *tuning-fork apparatus* with mirrors is simplified by the tuning-fork being replaced by steel springs which are inserted in suitable movable wooden columns.

Plate III. Apparatus for simplified demonstration.

A. ramified tuning-fork.

The same produces a sound composed of two tones, and marks the corresponding musical note direct on a smoked glass plate.

B, resonator with monometrical flame without membrane.

A conical shaped Resonator, which is held with the large opening downwards and is filled from the top with illuminating gas, which is allowed to escape through a small tube attached, and then ignited. The flame will react on the tones in the usual manner.

C, an igneous Kaleidophon.

Mr. Tollinger has shown that by fastening with wax a glimmering candle to the end of a prismatic steel spring, a very admirable demonstration for large audiences of this well-known experiment can be produced.

542a. Apparatus for **combining waves** in one plane. The resultant shown is that of two sets of waves (superposed) that differ by half a wave-length. *Chas. Brooke, F.R.S.*

542b. Apparatus for **combining waves** in two planes perpendicular to each other. The resultant shown is a right-handed elliptic helix. *Chas. Brooke, F.R.S.*

1229e. Apparatus for showing the longitudinal vibrations of a row of particles, (1) stationary, and (2) progressive.
Chas. Brooke, F.R.S.

The vibrations shown are those constituting the first harmonic subdivision of a pipe closed at one end.

543. Stationary Liquid Wave Apparatus and Sector Pendulum. *Frederick Guthrie.*

When such a system of stationary waves is formed in a deep cylindrical trough that the centre rises and falls as the edge falls or rises, the undulation is synchronous with a pendulum whose length is equal to the radius of the trough; and the accelerations of motion of the wave and pendulum are identical.

544. Wheatstone's Wave Apparatus. A complete instrument, showing plane, circular, and elliptical waves, the phenomena of interference, &c. *Elliott Brothers.*

544a. Apparatus to illustrate **Wave Motion.**
Rohrbeck and Luhme, Berlin.

544b. Apparatus to illustrate **Waves** and **Nodal Vibrations** of a row of **Mutually Influencing Particles.**
Sir William Thomson.

Each particle has only one degree of freedom, and is influenced by a force depending only on the relative positions of itself and of its next neighbours on each side. The shorter the wave-length the smaller the velocity of propagation of the wave.

The apparatus consists of a series of light rods loaded at each end, and strung transversely on two threads which form a bifilar suspension placed equidistant from the centre of gravity of each rod. The distance between the threads at any point is inversely proportional to the square root of the tension at that point.

545. Illustrations of Vortex Motion. Nos. 1 and 2 are vibrations ; Nos. 3–5 steady motion. (Proceedings of Royal Society of Edinburgh, 1 November 1875.) *Sir William Thomson.*

Series of 11 successive figures of a simple vortex ring, performing violent transverse vibrations of the first fundamental mode.

No. 2. Series of 11 successive figures of a simple vortex ring performing violent transverse vibrations of the second fundamental mode.

In Nos. 3–6 the motion is analogous to that of screw propellers backing, the vortex core being in each instance as it were the edge circumference of the screw propeller.

No. 3. Two-bladed screw.

No. 4. Three-bladed screw.

No. 5. Four-bladed screw.

No. 6. Trefoil knot described in Sir W. Thomson's papers on Vortex Motion (Transactions of Royal Society of Edinburgh for 1857 and 1858), and figured on the back of the "Unseen Universe," by Professors P. G. Tait and Balfour Stewart.

VI. FALLING BODIES AND PROJECTILES.

546. Drawing of a new Apparatus for demonstrating the lateral deflection of rotating conical projectiles.
Dr. Leopold Pfaundler, Innsbruck.

The conical projectile A turns within the horizontal frame B on its own horizontal axis, and can be put in rotation by pulling off the reel the string attached to *a*. Fastened, on the outside of the frame, on two little hooks, *b*, *b*, whose line of communication is perpendicular to the axis of rotation and passes through the centre of gravity of the entire body, are two threads, which join further up, and whose combined continuation is attached to a hook in the ceiling.

At the back there is a steering vane C with a counter-weight D, attached in such a manner that according to the position in which it is placed the line of the resultant of the atmospheric resistance will pass either above or below the centre of gravity of the projectile, without, however, altering the position of the centre of gravity itself. The vane can be turned on its axis, or be removed and replaced by a double vane C^1 with the two flat surfaces placed at right angles to each other.

The following experiments can be made with this apparatus :

1. *Stability of the Axis of Rotation.*

The apparatus is put in motion to swing in a curve of five meters length by taking hold of the vane and pulling it backwards, and then allowing it to drop. If the projectile does not rotate, it easily turns over and will deviate from its course by very slight causes ; if it rotates, it will remain parallel with its axis. The vane must be given a neutral position in regard to the atmospheric resistance.

2. *Lateral Motion.*

The apparatus is made to rotate to the *right* by the vane C being placed in an *upward* position, when the point in flying forwards will revolve to the *right*. If the direction of the rotation, or the position of the vane, be altered to the opposite course or direction, the point will revolve towards the *left*. If both are changed, the rotation will keep in the direction to the *right*.

3. *Lateral Deflection.*

The single vane C is replaced by the double vane C^1, the flat surfaces of which being placed in a vertical and horizontal position, the proceeding then is the same as described before.

Instead of the lateral motion, a parallel lateral deflection will be the result.

The latter experiment corresponds to the actual motion of the projectiles. The greater degree of velocity being equalized by the larger surface of the vane exposed to the atmospheric resistance.

682. Rotation Apparatus for determining the effect of Atmospheric Resistance on bodies of different shapes, particularly on projectiles. Constructed by Theodor Baumann, junior, Mechanical Engineer, Berlin.

Professor Dr. E. E. Kummer, Berlin.

(See "Abhandl. der Königl. Akademider Wissenschaften in Berlin, 1875"; "Über die Wirkung des Luftwiderstandes," by E. E. Kummer.)

547. Simple and Inexpensive Form of Morin's Machine for demonstrating the law of falling bodies. It can be made by an ordinary carpenter, at a moderate price, made by the exhibitor. *Dr. Stone.*

548. Apparatus by General Morin for the experimental demonstration of the laws of falling bodies.

M. Digeon, Paris.

549. Attwood's Machine with water clock attached.

The Council of the Yorkshire College of Science, Leeds.

The time is measured by a water clock, the orifice of which can be opened by means of a lever moving under the influence of an electro-magnet. The weights are supported by a thread grasped by a pair of iron pincers, which are kept shut by a spring, but can be opened by means of another electro-magnet included in the same circuit as that attached to the water clock, so that the water begins to flow and the weights to fall simultaneously. Another metal piece can be screwed on to the instrument. One of the binding screws with which it is furnished is insulated from it by a plate of ebonite pierced with a metallic rod in connexion with the binding screw, and on which rests one extremity of a lever in electric communication with the rest of the piece. This piece being included in the circuit the current cannot pass when the lever is raised, and the water clock is stopped as soon as this is effected by the falling weight.

549a. Attwood's Machine, with friction rollers and electro-magnetical release. *Ferdinand Ernecke, Berlin.*

549b. Attwood's Machine, with pendulum attached. *Rohrbeck and Luhme, Berlin.*

VII. FRICTION.

550. Apparatus for determining the Friction between Water and Air.

Professor Viktor von Lang, Vienna University.

The above consists of a heavy stand with one fixed and three movable arms. The fixed arm bears a short glass tube, from which water is made to flow in a continuous vein. A crosspiece of four glass tubes is united, air-tight, by its longest arm to the water-delivering tube; the opposite arm is directed downwards, and closed by a caoutchouc mouthpiece passing over the "aspirating tube." This latter is supported by the two lowest arms of the stand, the remaining fourth arm securing the crosspiece. The vein of water passing through the "aspirating tube" moves the air, the quantity of which is determined by the motion of a soap lamina in the "measuring tube." This tube is joined to one of the horizontal arms of the crosspiece, the fourth arm bearing a water manometer.

550a. Machine for the **Examination** and **Measurement** of the **Sliding Friction** caused by the **Motion** and the **Variable Velocity** on **Rails.** Constructed by Herr Jung, University of Giessen.

This machine includes :—

a. A board, with hooks for attaching a scale by means of a cord running on a roller, for the purpose of measuring the friction.
b. Two pairs of iron and brass rails, to be fixed to this board.
c. Three pairs of wooden rollers.
d. A pair of iron rollers.
e. A pair of brass rollers.

Physical Science Institute of the University of Giessen, Professor Dr. Buff.

This apparatus was originally used for measuring sliding friction. It is at the same time a convenient appliance for demonstrating the friction of the steam engine on the railway line.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

eres, from Book described under No. 599.

SECTION 5.—MOLECULAR PHYSICS.

WEST GALLERY, UPPER FLOOR ROOM Q

I. SPECIAL COLLECTIONS.

Hydrostamm (Hydrometer), with ballast of mercury, for liquids lighter than water. *The Accademia del Cimento.*

Hydrostamm (Hydrometer), with ballast of shots, for liquids heavier than water. *The Accademia del Cimento.*

The Hydrometer, No. 20, was probably used for determining the specific gravity of precious stones; by observing to what degree it was immersed without the precious stone, and with the precious stone placed upon the little metallic disc, suspended by the three little chains. This is also a fitting place to draw attention to the so-called "Palla d' Oncia" (ounce ball), of the Grand Duke Ferdinand, a glass globe which displaces very nearly an ounce of water. On the stem several rings were placed in order to make it sink, and then by the number of these rings, it was known what the specific gravity of the liquid was into which it had been immersed.

Besides the Hydrometer, No. 21, for determining simultaneously the temperature and the corresponding specific gravity, other ones of the Accademia del Cimento, which are true thermometers, having in addition the scale of graduation of hydrometers.

Hydrostamn (Hydrometer), with a small metallic balance, the first idea of Nicholson's areometer.
The Accademia del Cimento.

Photograph of the **Hydrostamm (Hydrometer),** enclosing a thermometer. *The Accademia del Cimento.*

Ball of Metal, filled with water, and prepared by the Accademia del Cimento to serve in the experiments for the compression of water. *The Accademia del Cimento.*

Ball of Metal, still containing some water that served for the experiments of the Accademia del Cimento on the compression of water. *The Accademia del Cimento.*

Among the many experiments made by the Accademia del Cimento for the compression of water, either by means of rarefied air, by the pressure of mercury, or by the force of percussion, the last one which was carried out with a ball of very thin silver, has attracted the most universal attention. When beaten with a hammer, the water "sweated through all the pores of the "metal, like quicksilver spouting through some skin in which it was being "squeezed."

Two Tubes of Torricelli, one of which ends in a sphere. They served him for his experiments on atmospherical pressure in 1644. *The Accademia del Cimento.*

Galileo, by condensing air, had demonstrated its weight, and in his dialogue on the resistance of solids, he says of water, that in suction-pumps, it does not rise higher than about 18 braccia, leaving the space above empty. Torricelli, pondering over this fact, was led to think of what would happen, if, in the place of water, mercury, which is so much heavier, were used; for he argued that by its means there would be much greater ease in obtaining a vacuum, in a much shorter space than that necessary for water. He then made a long glass tube of the length of about two braccia, which terminated at one end in a ball, likewise of glass, and remained open at the other; through this aperture he proposed to fill the tube and the ball completely with mercury; and then holding it with his finger, and turning it upside-down, submerge the orifice of the tube below the level of more mercury in a large vessel; and that being done, take away his finger and open the tube, thinking that the quicksilver would detach itself from the ball, and having glided down and remained suspended according to the various calculations, at about the height of $1\frac{1}{4}$ braccia, would in all probability leave a vacuum in the ball above and in part of the tube. He communicated this thought to his great friend Viviani, who, most anxious to see the result, agreed to the experiment, which he himself carried out, and was hence the first, about a year after Galileo's death, to see Torricelli's ingenious idea confirmed by the fact. He hastened to his friend, who, most joyful at the news of this evidence, was all the more persuaded that the weight of the air was really that which was in equilibrium with the column of water or mercury. Indeed, being asked by Viviani what would have happened if the experiment had been made in closed space, Torricelli, after having reflected for a short time, answered, the same thing; since the air is already compressed in it. This most important discovery was communicated by the author himself to Ricci in Rome, and by Ricci to Sig. de Verdus, who, in his turn, made Padre Merseune acquainted with it, from whom Pascal learnt it, and made it famous, as everyone knows, in his celebrated Puy-de-Dôme experiment. Torricelli himself in a letter to Ricci, observes; "that it would be possible, by means "of his instrument, to ascertain when the air was lighter or heavier; and "that it might be the case that air, which is most heavy upon the surface "of the earth, becomes more and more light and pure as we rise higher and "higher to the tops of the loftiest mountains." And Carlo Beriguardi in his "Circolo Pisano," published in 1643, says; "that the tube of quicksilver "leaves more space empty, when placed at the top of a tower or of a "mountain, than at the foot."

STANDARDS OF THE HYDROMETERS AND THERMOMETERS USED BY GOVERNMENT OFFICERS IN HOLLAND.

Exhibited by Dr. J. W. Gunning, Professor of Chemistry at the "Athenæum illustre," Amsterdam.

579. General Hydrometer (No. 1), with open stem and variable weight. Every degree has a bulk equal to $\frac{1}{100}$ of the part of the hydrometer below zero. When this instrument, having the arbitrary weight = W grammes, marks *a* degrees in a liquid, the apparent specific gravity of that liquid at the observed temperature will be $= \frac{W}{(100 + a)1{\cdot}014608.}$

580. Instruments (Nos. 2 and 3) for ascertaining the strength of alcoholic liquors. The degrees are the same as in No. 1, but the weight is not variable, and the zero is the immersion point at 15° C. in a liquid, of which the specific gravity at that temperature is equal to the specific gravity of pure water at 4° C. Tables are added, those of Professor von Baumhauer (1863), used in Holland; those of the exhibitor (1873), used in the colonies. The latter are based on the researches of Mendelejeff. Phil. Mag. (4) XXIX. 395.)

581. Hydrometer (No. 4), for liquids of a specific gravity greater than 1. The construction is the same as in Nos. 2 and 3. The Beaumé scale is added. Used for solutions of salts and sugar juices.

582. Hydrometers (Nos. 5 and 6), for ascertaining the specific gravity of seed oils and of petroleum, allowing immediate application of correction for temperatures above or below 15° C. (For description see Scheik. Bijdragen door J. W. Gunning, Amsterdam, 1867.31.)

583. Densimeters (Nos. 7, 8, and 9), with flat stems. The zero is the same as in Nos. 2 and 3.

584. Hydrometer (No. 10), for preparing a liquid having at 15° C. the specific gravity of pure water at 4° C. The instrument is made in the following manner:—Through the open stem shots are introduced till the instrument floats at the mark on the stem in pure water of 15° C. The weight of the instrument is then increased in the ratio 0·99915 : 1, in consequence of which it floats at the same mark at 15° C. in a liquid having at that temperature the specific gravity of pure water at 4° C.

585. Trough for comparing Hydrometers.

Thermometers. The instruments have the Celsius' scale. By their mode of construction they possess the following advantages: (1.) They may be turned upside down and shaken in any manner without breaking the column of mercury. (2.) Though newly made, the zero is not subject to displacement.

The former advantage is obtained by filling the tube and the upper space with perfectly dry air, free from dust, as highly compressed as possible.

The latter advantage is secured by placing the bulbs of the newly made thermometers in a bath of paraffin, heated slowly to 100° C. and then allowed to cool slowly and in succession sixty to a hundred times.

II. AIR PUMPS AND PNEUMATIC APPARATUS.

597. Air Pump, by Otto von Guericke, with stand.
Professor Dr. Lepsius, Berlin.

606. Otto von Guericke's Air Pump.
"Collegium Carolinum," Polytechnic School at Brunswick, Professor Dr. H. Weber.

The earliest trustworthy information respecting *Otto von Guericke's* original apparatus is contained in a list of the physico-chemical apparatus of the *Collegium Carolinum*, at Brunswick, of the year 1816. In this list it is stated that this apparatus was obtained from the legacy left by Aulic Councillor *Beireis*, in Helmstedt. According to a special ordinance of His Highness *Frederich Wilhelm*, Duke of Brunswick, dated 8th October 1814, the collection of physical, mathematical, and astronomical instruments acquired from the legacy left by *Beireis*, physician in ordinary, at Helmstedt, was exhibited in the rooms, and by a later ordinance dated 9th March 1815 incorporated with the collections of the ducal *Collegium Carolinum*. The air-pump has been preserved unaltered, with the exception of the lever and the piston attached to it, the former having been replaced by a new one of the same construction, and the latter by a wooden one, in the year 1864. The pump has been described and faithfully represented by a drawing in a work published by *Otto von Guericke*, entitled "Ottonis de Guericke Experimenta nova (ut vocantur) Magdeburgica de vacuo spatio Amstelodani," 1672, cap. IV. p. 75, Tab. VI., in which work he also (p. 122) successfully refuted the assertion of *Augustus Hauptmannus*, doctor of medicine, in his "Berg-be-deneken, anno 1658, Lipsiae," "that it would not be possible to either angel or devil to bring about a vacuum." This work is in the possession of the ducal library, at Wolfenbüttel. But, previous to this air-pump, *Otto von Guericke* had constructed one more simple, consisting of only one cylinder and a piston, which is said to be in the library at Berlin (*see* No. 597). The difficulty, however, connected with the motion of the piston, the resistance of the air against the free piston being so great that it required two strong men to pull it out repeatedly, p. 75, induced him to contrive their second improved construction. The receiver stand at present in use was unknown to *Otto von Guericke*. In order to produce a vacuum, he employed a hollow copper ball with stopcock,* which was placed in the axis of the barrel. It was exhausted, and screwed on to other vessels, which, by the repetition of the process, were also exhausted. The pail of tin-plate attached to the lower end of the barrel, as well as the copper bowl fastened to the upper end of the barrel, were filled with water or oil, in order to effect a greater tightness.

607. Two large Magdeburg Hemispheres of copper.
Professor Dr. H. Weber, Brunswick.

The two large hemispheres of copper are those of which *Otto von Guericke* states, in page 104, Tab. XI., that after their exhaustion they could not be separated by the united strength of 16 horses. They have a diameter, as mentioned in the work alluded to above, of nearly $\frac{3}{4}$ Magdeburg ells, or, according to a second more exact statement, 0·67 Magdeburg ells.

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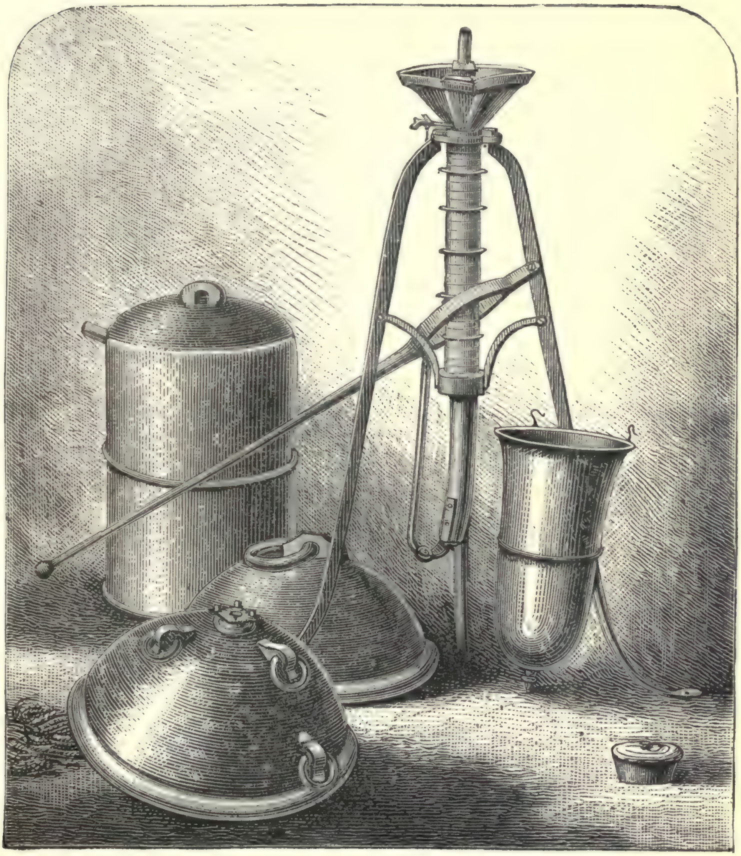
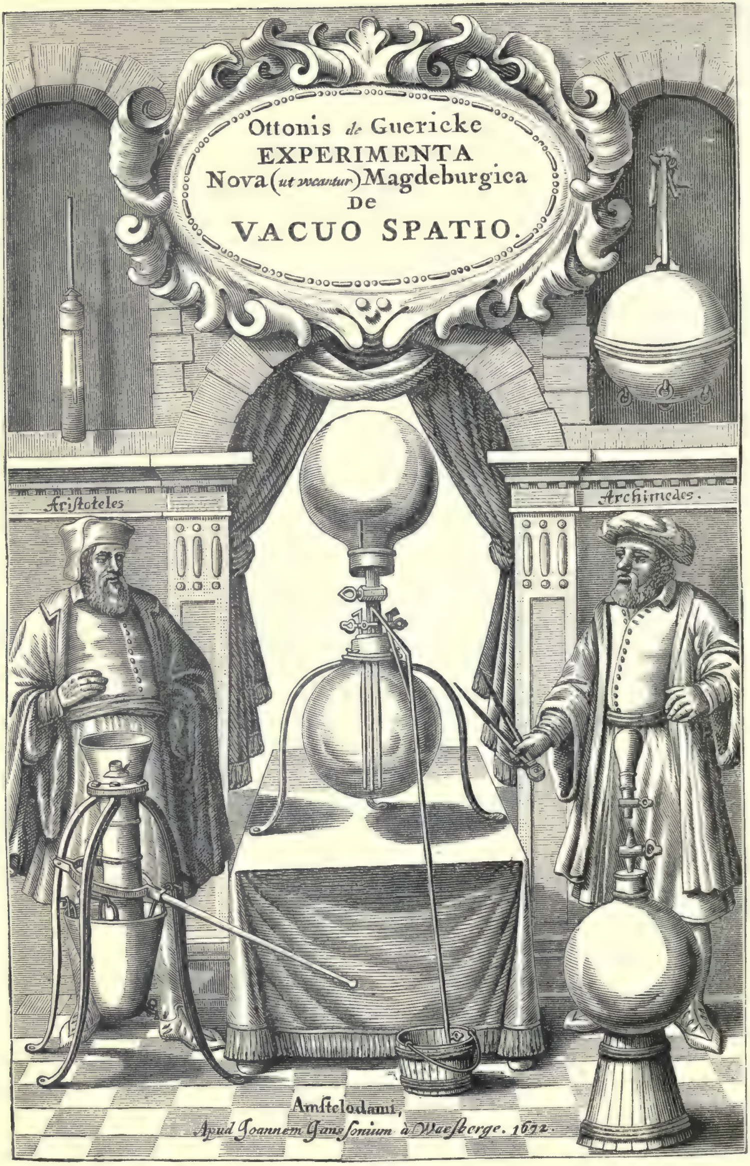
* This ball (page 88, Tab. VIII.), as well as a pair of still larger Magdeburg hemispheres, nearly an ell, Magdeburg measure, in diameter, which 24 horses had not the power to separate (page 105), and, lastly, a copper boiler with inserted piston, which, when the air below the same was withdrawn, 50 men were not able to lift or to pull up (page 109, Tab. XIV.), are likewise enumerated in the list, but are no longer to be found.

[*To face page* 158.]



Otto von Guericke's Air Pump, and Magdeburg Hemispheres, described under Nos. 606 and 607.

[*To face page* 159.]



Ottonis *de* Guericke
EXPERIMENTA
Nova (*ut vocantur*) Magdeburgica
DE
VACUO SPATIO.

Amſtelodami,
Apud Joannem Janſſonium à Waeſberge. 1672.

Ariſtoteles
Archimedes.

Title-page of Book described under No. 599.

608. Two smaller Magdeburg Hemispheres of brass.
Professor Dr. H. Weber, Brunswick.

The two smaller hemispheres of brass were used for experiments with weights (page 106, Tab. XII., of Otto von Guericke's "experimenta nova").

598. Two Magdeburg Hemispheres.
Professor Dr. Lepsius, Berlin.

599. "Ottonis de Guericke Experimenta nova (ut vocantur Magdeburgica) **de Vacuo spatio."** Primum a R. P. Gaspare Schotto e Societate Jesu et Herbipolitanae Academiae Matheseos Professore : nunc vero ab ipso Auctore perfectius edita, variisque aliis Experimentis aucta. Quibus accesserunt simul certa quaedam de Aeris Pondere circa Terram, de Virtutibus mundanis, et Systemate mundi planetario, sicut et de Stellis fixis, ac Spatio illo immenso quod tam intra quam extra eas funditur.

Amstelodami apud Joannem Janssonium à Waesberge, Anno 1672. Cum Privilegio S. Caes. Majestatis.
Professor Dr. Lepsius, Berlin.

587. Air Pump, with double barrel (1662), by Boyle.
Royal Society.

622. Diagram of Von Guericke's Air Pump. Invented 1654. *A. Galletly, Edinburgh.*

It consisted of a globe of copper, with a stopcock, to which a pump was fitted.

The pump-barrel was entirely immersed in water to render it air-tight. This was the earliest of all air-pumps.

623. Diagram of the First English Air Pump, constructed in 1658–59 by Hooke and Boyle, but mainly by the former.
A. Galletly, Edinburgh.

As shown in the diagram, it had a single barrel, in which was a piston worked by a rack and pinion. In working it the valve G of the cylinder was shut, while the stopcock L of the receiver was open, during the descent of the piston. When the piston was driven home, L was shut and G kept open. In this air-pump a vacuum was produced slowly, and was imperfect at best.

624. Diagram of the Second English Air Pump, constructed by Boyle and Hooke in 1667.
A. Galletly, Edinburgh.

The piston was worked by a rack and pinion like the first English air-pump, but in this one the barrel was kept under water to keep the leather of the piston always wet.

The piston had an aperture at F and a stop-cock at I, which were worked as in the first English air-pump.

625. Diagram of Papin's Air Pump. 1676.
A. Galletly, Edinburgh.

The diagram represents only the working parts of the instrument, without the frame supporting them. This air-pump had the great advantage over earlier forms of having two barrels, in which case, as the air becomes exhausted, the resistance which it offers to the ascent of one piston is nearly balanced by the force with which it compels the other to descend. This air-pump was worked by moving the feet alternately up and down in stirrups.

626. Diagram of Hauksbee's Air Pump. 1703–9.
A. Galletly, Edinburgh.

This instrument, like Papin's, had two barrels, but the stirrup arrangement and pulley are replaced by racks on the piston rods, and a pinion moved by a handle, as in the modern double-barrelled air-pump. These diagrams 622–626 were made to illustrate a paper on the early history of the air-pump, published in the New Philosophical Journal, April 1849, by the late Dr. George Wilson of Edinburgh.

687. Diagram of Torricellian Vacuum. 1644.
A. Galletly, Edinburgh.

603. Air Pump, by J. van Musschenbroek, and two Magdeburg hemispheres.
The Royal Museum, Cassel, Dr. Pinder, Director.

1. *Air-pump, with obliquely placed cylinder, on Senguerd's system.*

This air-pump is, perhaps, the oldest of the kind existing, with a "four way" stop-cock. It was constructed in the year 1786, by *Jan van Musschenbroek*, in Leyden, and bears the Musschenbroek arms, namely, the "*Oosterche* lamp," and the crossed keys; the armorial bearings of the city of Leyden. The invention of the four way stop-cock notoriously originated with *Senguerd*, who, from the year 1675–1724, was a professor at Leyden. The air-pump, preserved in the Physical Science Cabinet of that town, which, according to the inscription, was constructed by *Samuel Musschenbroek*, in the year 1675, and which has a four way stop-cock, is there considered to be the first of the kind, but could not at first have been provided with this adaptation since it was invented at a later date. This appliance must have been adapted to it only at a later period. *Senguerd* first described this kind of cock in the second edition of his "Philosophia Naturalis," which was published at Leyden in the year 1685. In his work, "Rationis atque Experimentiæ Connubium," which was published at Rotterdam in the year 1715, he states that he made the invention in 1675, and that in 1679 he had the air-pump executed by a skilful artizan. That this artizan was *Samuel Musschenbroek* is proved by a notice in the handwriting of *Petrus van Musschenbroek*, which he wrote in a copy of his work entitled, "Beginselen der Naturkunde." However, *Senguerd*, in the first edition of his work, "Philosophia Naturalis," which appeared in 1680, and of which a copy is in the possession of the Library of the University at Utrecht, makes no mention at this time of the cock, but gives an illustration of an air-pump of the original construction of *Otto von Guericke*. That the air-pump was constructed is plain, from a record of *Uffenbach's*, describing the "Laboratorium Physicum" of the University of Leyden, dated the 19th January 1711:

"In the centre stood an elevated table. Upon this table there stood an "'Antlia pneumatica' of considerable size, of *Samuel Musschenbroek's* old "invention, inclined with a 'cista' to put water in." Although the words "from the invention of *Sam. Musschenbroek*" may also have reference to the air-pump, which is still preserved in the Physical Science Cabinet at Leyden, yet the description does not tally with it, inasmuch as its cylinder is perpendicular, and stands next to an elevated table which carries the plate, and is consequently united with it in one apparatus. It is possible that *Uffenbach*, who was not an adept in that science, was only induced to make use of the above-mentioned expression on seeing the arms of the firm of *S. v. Musschenbroek*. But how it happened that he did not see the other air-pump, since he mentions a third air-pump, of *Boyle's* construction, still in existence, is rather obscure, as *De Volder*, *Senguerd's* predecessor in the professorship of physics at Leyden, who himself laid the foundation of the establishment of the Physical Science Cabinet at Leyden, must have worked in the same laboratory. "There are given here (in the laboratory), as we were assured," continues *Uffenbach* in his narratives, "'Lectiones publicæ' four times a week " by *M. Senguerd; De Volder*, however, it was stated, has had larger " audiences, as he was more artful ('curieuser') in his experiments."

Senguerd did not deliver these lectures until after *De Volder's* retirement, in 1705. *De Volder* died in 1709, and it is possible that the air-pump was at that time in course of reconstruction. *Senguerd's* air-pump, therefore, as it is not to be found in the Physical Science Cabinet at Leyden, must, in all probability, have been private property; and it is possible that, like many old instruments, it is still somewhere in private possession in Holland. So long, however, as it is not discovered, the Cassel Museum may lay claim to the distinction of having in its possession the air-pump with the oldest four-way stop-cock. For although *Senguerd* had his air-pump made in 1679, the description of it did not appear until 1685, when it excited much attention. Christian Wolff, in 1718, had one constructed exactly according to the same pattern, by Leupold at Leipsic, which may still be seen in the Physical Science Cabinet of the University at Marburg. It is very singular that Musschenbroek, in his manifold writings, never as much as mentions Senguerd's air-pump. That, of course, this omission cannot be construed into an argument against the priority of *Senguerd* is plain from the subsequent remarks in the above-mentioned autograph notice, in which it is stated that "in the year 1679 *Senguerd* and the same *Samuel* " *Musschenbroek* had under consideration air-pumps of another kind, which " were afterwards improved by my father, *Jan van Musschenbroek*, and by " my brother" ("in den jaare 1679 heeft de Heer Senguerd met dienzelven " *Samuel Musschenbroek* lucht pompen van een anderen aart bedagt, welke " geduurig naderhand door mynen vader Jan van Musschenbroek, als door " mynen broeder verbeterd zyn.") It seems as if family partiality had influenced him.

The air-pump is accompanied by two powerful Magdeburg hemispheres with which the experiments of Otto von Guericke, of the Regensburg Diet, were repeated at Cassel.

604. Compression Machine, for throwing bombs.

The Royal Museum, Cassel; Dr. Pinder, Director.

This is one of the most ancient instruments in the possession of the Cassel Museum. On the 16th November 1709, von *Uffenbach* saw it in the Art Museum of Landgrave *Karl*. It was to serve for the purpose "of throw- " ing lighted grenades through the air to a distance of more than 100 yards, " with the usual effect." At that time some of its former defects had just been repaired. "Twelve grenades can be thrown one after another with great " rapidity. But, because the air is continually diminishing, the last, as may " be easily conceived, do not go as far as the others." This instrument, which acts on the principle of an air-gun, the brass ball carrying a funnel upon which the grenades were placed, and by which also red hot shots could be thrown without any danger to the men serving it, is of historical interest, as it is a surviving witness of the joint labours of *Papin* and the Landgrave *Karl*, and it even transports us to the midst of that catastrophe which put an end to Papin's activity. It was a similar machine, with which *Papin* contemplated throwing bomb shells by means of steam, which exploded in his laboratory. "The other and greatest misfortune was that, having undertaken "to shoot the same with steam as with powder, he might have provided a "weapon of great destructive power. The machine prepared for that pur"pose, however, exploded, not only demolishing a great part of the labora"tory, and mortally wounding several men (one among whom had his jaw"bone carried away), but Landgrave Karl himself, who is a very curious "lord, intent upon seeing and examining everything minutely, might have "been hit, and have lost his life, had not His Highness been accidentally de"tained by other affairs and come to the laboratory later. On this occasion "Papin was dismissed from his service."

614. Air Pump with two Barrels. The first pump of the kind ever constructed. It is an exhausting and a condensing pump, and was made for King George III. in 1761.

The Council of King's College, London.

618. The Abbé Nollet's Air Pump.

Conservatoire des Arts et Métiers, Paris.

586. Hand Pump, Regnault's System improved.

Geneva Association for the Construction of Scientific Instruments.

Exhausting and forcing hand pump. The hand pump, constantly used in laboratories, has now attained a satisfactory practical shape, from which not much deviation is possible. Its general proportions are determined by the consideration of how best use can be made of muscular power, with simplicity and facility of carriage of the apparatus. Silken valves, as being too perishable, are excluded and replaced by cones of metal and leather. All the movable parts, piston and valves, are equally accessible. Three cocks effect the complete cutting off of all communication between the pump and the exhaust and the compression receivers, as well as restore direct communication, either between both or one of these and the atmosphere. If rarefaction is required in the compressing vessel, or *vice versâ*, without disturbing the tubes of communication, the relative position of the valves must be inverted, which may be done in a few minutes, or else a change cock must be joined to the pump.

For effecting all communication between the pump and its receivers, a screw flush joint is always used, which is very safe, and can be fitted to tubes made of india-rubber, copper, or lead. This avoids the deterioration of the india-rubber, which is unavoidable on account of the constant action of fastening the joints, especially as it is rarely that a thoroughly air-tight joint can be made with india-rubber alone.

588. Sprengel's Mercury Pump.

Prof. Dr. R. A. Mees, Director of the Physical Laboratory of the University of Groningen.

This instrument differs from all others—(1) in the numerous curvatures of the tube through which the mercury falls. These augment the exhausting power of the pump, while the air bubbles, which are carried away with the mercury, and which, when near vacuum, are so minute that they remain hanging on the walls of the tubes before coming down, assemble in the curvatures, until their size is so far augmented that they are carried away by the falling mercury. (2) The instrument is provided with a peculiar stop-cock with two perforations, whereby the flowing of the mercury is regulated and the acquired vacuum preserved. To effect this, the stop-cock is furnished with two iron rings, which float on the mercury, and, falling with it, close the opening of the stop-cock. By means of the second perforation of the stop-cock the instrument can be joined to an ordinary air pump, and the operation abridged by a partial exhaustion of the air. To produce a more complete vacuum than can be obtained by an ordinary air pump, the stop-cock is turned half round, and, when the vessel surrounding the stop-cock is filled with mercury, the Sprengel pump begins to act.

589. Aspirator, moved by clockwork with sulphuric acid; U tube for determining accurately the amount of moisture in the atmosphere by the use of the balance. *Dr. Andrews, F.R.S.*

The amount of moisture at different periods of the day, or the average amount in 24 hours, may be determined with great precision by means of this arrangement, which the exhibitor proposed many years ago for use in meteorological observatories, instead of the present defective methods.

590. Spirator. Designed to get a constant current and known volume of air driven or drawn over a body. *Frederick Guthrie.*

The principle resembles that of "Tantalus' cup." A constant current of water enters a flask, and (1) drives out its own volume of air through a mercury trap; (2) when the flask is filled up to a certain point, a siphon acts, and, in emptying the flask, draws air in from another tube.

590a. Apparatus for collecting Gases without exercising upon them either pressure or rarefaction. *George Gore, F.R.S.*

612. Apparatus for Air Pump. An air-gun supported by two vertical mahogany pillars and cross-bar, by means of which it may be adjusted to any angle. *The Council of King's College, London.*

613. Apparatus for Air Pump. Metal condenser with glass ends, large enough to take a pair of four-inch Magdeburg hemispheres with fittings, and a metal lever to which weights may be attached to measure the pressure of the air, either when compressed or at its ordinary pressure. *The Council of King's College, London.*

592. Drawing of Mercurial Air Pump (1872). *J. P. Joule, D.C.L., F.R.S.*

By alternately lifting and lowering the bulb attached to the flexible tube, the air being dried by the admission of sulphuric acid through a glass valve at the upper part of the perpendicular tube, a very excellent vacuum may be obtained in a short time.

592a. Sprengel's Mercurial Air Pump, improved form. *E. Cetti & Co.*

592b. Modification of Sprengel's Air Pump, with air-trap and means of supplying sulphuric acid, in order to clean out the fall tube while the pump is in use. *Prof. H. McLeod.*

593. Mercury Air Pump. *Dr. H. Geissler, Bonn.*

594. Photograph of an Air Pump, the exhibitor's construction (in frame).

C. Staudinger and Co., F. W. von Gehren, Giessen.

This air-pump has a double-acting barrel of 10 cm. diameter and 32 cm. in height. The motion of the piston is effected by the rotation of a fly-wheel in one direction.

595. Hydro-dynamical Air Pump.

Baron Dr. von Feilitzsch, Professor at the University of Greifswald.

An ordinary air-pump receiver communicates with a tube through which mercury is passed with great rapidity in such a manner as to flow in through a small aperture and to flow out again through a wide opening. A vacuum will thus be produced under the receiver.

596. Mercury Air Pump, with valve, on Mitscherlich's system. *Prof. Dr. Mitscherlich, Münden, Hanover.*

(See "Poggend Ann. der Chem. und Phys.," vol. 150, p. 420.)

600. Air Pump. *Charles Gustavus Pinzger, Breslau.*

This air-pump is provided with a double acting piston, and so arranged that it can be used as an exhausting and as a compressing pump. In the former case the barrel is placed in a diagonal position, and the pump provided with glass plate and stop-cock, but if the plate with the cock be screwed off, and the hose-screw attached to the wooden stand screwed on, and the barrel detached from its support and placed perpendicularly, the pump can in that case be used as a compression pump. Plate with cock are meanwhile screwed again on the wooden stand. The cock below the barrel, by reason of its parallel position, effects with this the connexion between barrel and plate, and in its upward position, the communication between barrel and the external air; and, lastly, in its downward position, the communication between the plate and the external air.

601. Mercury Air Pump, on Professor von Jolly's system,

Prof. von Jolly, Munich.

This air-pump has been described by G. Jolly in Carl's Repertorium, 1865. As regards the alterations which have since taken place, and which have been introduced in the apparatus exhibited, a special description has been added to the object.

602. Apparatus for Demonstrating Mariotte's and Dalton's Law.

Prof. Baron Dr. von Feilitzsch, University of Greifswald.

This apparatus enables the laws in question to be demonstrated when the pressure is above or below that of the atmosphere. A glass tube open at the upper end, and a glass gauge tube, which can be closed at the upper end by a stop-cock, communicate by means of a long gutta-percha tube, and can be displaced on a vertical scale. These are partly filled with mercury, the latter tube containing the gas to be tested, or the combination of gases and vapours, when by raising or lowering of the first tube, the level of the mercury can be changed as required, and the resulting volume of gas observed.

The apparatus can be easily adapted to all kinds of experiments, at pressures either above or below that of the atmosphere.

605. Suction Pump, on an iron stand.

Ferdinand Ernecke, Berlin.

605a. Suction Apparatus. Two small pieces of apparatus to illustrate the deficiency of pressure attending a high velocity in a stream of air. *Lord Rayleigh.*

By blowing through the electrotyped copper tube a suction of 6 inches of mercury may be realised at the narrow part.

In the second arrangement the novelty consists in the cap at the end of the brass tube, by which the efficiency is increased.

609. Double Cylinder Air Pump, with Babinet's stop-cock, cylinder 170 mm. high, 60 mm. wide, with manometer and glass plate of 200 mm. diameter, on a mahogany board, with the following auxiliary apparatus :—

1. Pair of Magdeburg hemispheres of glass.
2. Electric egg, consisting of two parts, with arrangement for carbon points.
3. Double mill.
4. Balloon, with bell.
5. Balloon, for the gravity of the air.
6. Fountain.
7. Quicksilver.
8. Ring.
9. Dasimeter.
10. Falling tube.
11. Heron's ball.

Warmbrunn, Quilitz, and Co., Berlin.

610. Apparatus for Lighting, on the system of Döbereiner, with contrivance for drying the gas.

Warmbrunn, Quilitz, and Co., Berlin.

610a. Water Vacuum Pump, invented by H. Sprengel in 1863. *Hermann Sprengel.*

610b. Air Pump and two receivers, by Staudinger, Giessen.

Chemical Laboratory, University of Berlin; Prof. A. W. Hofmann, Director.

611. Water Pump, either for exhausting or for compressing air. *Joseph Conquet.*

This apparatus can be used either in place of an air pump, or in place of bellows. Water at a pressure of two atmospheres is required for working it.

615. Electrical Apparatus belonging to Air Pump. Vertical cylinder electrical machine with two leather rubbers. The apparatus is so constructed that the cylinder may be enclosed in a large glass receiver, which can be exhausted.
The Council of King's College, London.

616. Large Air Pump, arranged for producing the ordinary vacuum or a dry vacuum of a millimetre of mercury, and also for producing ice. *M. Carré, Paris.*

616a. Small Air Pump, also capable of being transformed at will into a compression pump. *M. Carré, Paris.*

617. Apparatus for producing ice by vacuum and sulphuric acid. *M. Carré, Paris.*

619. Hydraulic Press of Copper and Glass (for demonstration). *Luizard, Paris.*

620. Apparatus for Compression. *Luizard, Paris.*

620a. Model of an Air Compressor, which may also be used as a water meter. *M. Eugene Bourdon, Paris.*

621. Air Pump for Double Exhaustion (Babinet's principle). *Luizard, Paris.*

621a. Model of Pneumatic Machine.
M. Loiseau, jun., Paris.

627. Fick's Spring Manometer. *Weber, Würzburg.*

630. Air Pump, made by Spencer & Sons, Dublin.
Prof. W. F. Barrett.

This air pump has no valves between the barrels and the receiver, hence it is free from regurgitations of air, and is capable of making a vacuum nearly equal to that obtained by means of Sprengel's air pump. The ends of the pistons and barrels are conical, and, when they are in contact, no cavities remain. All the air in the barrels is therefore expelled at each stroke of the piston; the effect is the same when it is highly rarefied. The horizontal portions of the pump admit of the barrel being brought into close connexion with the plate, and leaves the valves accessible for cleaning or repairs.

630a. Single Barrel Air Pump. *James How and Co.*

630b. Air-pump on Babinet's system. *Dr. Stone.*

680a. Improved **Portable Spireometer.** *E. Cetti & Co.*

III. OSMOSE, DIALYSIS AND DIFFUSION.

631. Electric differential Osmometer. Engelmann.
Prof. Engelmann, Utrecht.

Two glass vessels of quadrangular section, possessing in the plane ground surfaces facing each other a round aperture 30 mm. diameter, and each containing an electrode; a platinum disc 30 mm. diameter. Between the two vessels the cell is placed, a plane parallel plate of ebonite, furnished with a transverse perforation 30 mm. diameter, communicating with a short brass top, upon which a rise-tube, manometer, etc. can be screwed. The membranes or porous plates, whose electric osmotic permeability is to be compared, are placed between the cell and the glass vessels, the whole being secured by two brass vices. Both vessels and the cell are now filled with the same fluid. Inelastic partitions, such as clay plates, must, in order to prevent breakage and leakage, be provided, on each side, with an elastic ring (india-rubber or bladder).

Thin, very pliable, membranes, *e.g.* skin of a frog, are secured between sieve-like perforated plates of ebonite to prevent bending.

The apparatus is used to demonstrate:

1st, the fact of electric osmosis.

2nd, the specific influence of the membrane; the rise and fall of the fluid in the cell shows which of the two membranes possesses the greater electric osmotic permeability. On removing one of the partitions, the apparatus becomes an ordinary osmometer.

(Onderzoekingen gedaan in het physiologisch laboratorium der Utrechtsche Hoogeschool. Derde Reeks, II., 1873, p. 365, etc.)

632. Osmometer, illustrating the transpiration of gases through capillary tubes. *Prof. W. F. Barrett.*

This is an apparatus constructed under the direction of Professor Sullivan for illustrating the law of the transpiration of gases. The diaphragm is made of a number of short lengths of capillary tubes.

IV. CONDENSATION AND SOLUTION OF GASES.

633. Addams' Apparatus, for condensing and solidifying carbonic acid. *William Sykes Ward.*

634. Apparatus used in 1857 for Liquefying Ice by Pressure at temperatures below −65° C.
Prof. Mousson, Zurich.

A small cylindrical chamber, hollowed out of a strong piece of steel, is filled with water containing a movable metallic index. When the water is frozen, the chamber is closed by means of a soft copper cone, subject to the action of a strong screw. The apparatus is then *reversed.* The chamber merges into a long, slightly widening cone of soft copper, on which a short steel rod presses by means of a powerful screw-nut acting on the principal piece, and a double lever a metre in length. If the chamber be opened, after the pressure is removed, the index is found to have been carried over to the other end, as a proof that the ice has been reduced to a liquid state. Soft copper is the only means of closing under excessive pressures.

The experiment can be successfully made at − 18° C.

635. Original Model of the Fluid Vein of Messrs. Poncelet and Lescros. *Conservatoire des Arts et Métiers, Paris.*

636. Original Thilorier Apparatus for liquefying carbonic acid, 1857. *Conservatoire des Arts et Métiers, Paris.*

637. Apparatus for the demonstration of Boyle and Marriotte's law to a class. *Prof. W. F. Barrett.*

The mercury contained in the upper iron reservoir can be admitted to the tube through an apertnre closed by a valve that is moved by pulling the string. The eye is kept level with the air chamber. Equality of pressure with the atmosphere is readily obtained by means of the stopper closing the lower bent tube or air chamber.

638. Compression Pump and Receiver. An apparatus for the liquefaction and solidification of gases.

H. Lloyd, Trinity College, Dublin.

640. Apparatus employed in the researches of Dr. Andrews on the continuity of the gaseous and liquid states of matter, and on the properties of matter at high pressures and varied temperatures. *Dr. Andrews, F.R.S.*

This apparatus consists of two cold-drawn copper tubes of great strength, communicating by a horizontal passage, and having massive end-pieces above and below, firmly bolted on with leather washers interposed, so as to be able to resist any pressure. The upper end-pieces are traversed by fine glass tubes, the junction between the glass and metal being made tight by a peculiar system of conical packing. The exposed parts of the glass tubes have a capillary bore, and, if sufficiently fine, will bear a pressure of 500 atmospheres or more without bursting. One of the tubes contains air or hydrogen, and serves as a manometer, the other contains the gas or liquid to be examined. The lower end-pieces carry well packed steel screws, which produce the pressure by compressing the water with which the apparatus is filled. The temperature of the air or hydrogen in the manometer, and that of the gas or liquid under examination, can be varied at pleasure by enclosing the glass tubes in outer cylinders of glass, or, where accurate readings are required, in rectangular vessels with plate-glass sides. With this apparatus, accurate measurements can be made to 500 atmospheres, or even higher pressures, and, with a slight modification, at any temperature which glass will bear without softening.

641. Single Apparatus, adapted to exhibit the properties of gases and liquids under different conditions of pressure and temperature, but without measuring the pressures employed.

Dr. Andrews, F.R.S.

This apparatus is similar in construction to the compound form last described.

641a. Original Apparatus, by Despretz, by the help of which he proved the difference, shown by gases, in relation to the law of Marriotte. *The Faculty of Sciences, Paris.*

641b. Original Apparatus, by Gay Lussac, for ascertaining the elastic force of gases and vapours.
Polytechnic School, Paris.

641c. Apparatus, by M. Dumas, for illustrating the density of vapours. *Conservatoire des Arts et Métiers, Paris.*

642. Sulphurous Acid Tube, to exhibit the flickering striæ which occur, from slight changes of pressure, near the critical point of temperature. *Dr. Andrews, F.R.S.*

643. Model, constructed by Professor J. Thomson, to illustrate the results of the experiments by which Dr. Andrews first established the continuity of the gaseous and liquid states of matter.
Dr. Andrews, F.R.S.

V. HYDROMETERS.

644a. Regnault's Apparatus for estimating the specific gravity of solid bodies.
Golaz, 24, *Rue des Fosses, St. Jacques, Paris.*

645. Compensation Salinometer.
H. Hädicke, Demmin, Pomerania.

The compensation salinometer is an areometer especially constructed for measuring the saliferous contents of sea water, or of the water in steam boilers, the readings of which are independent of the temperature of the respective fluids. The dimensions of the same have been so calculated that the increase of the volume of the instrument effected by the expansion of all its constituent materials (*i.e.*, aluminum, or iron and mercury) will avoid the deeper immersion which in the instruments of the ordinary construction would take place in consequence of an increase of the temperature of the fluids.

646. Apparatus for measuring the Density of Liquids.
Prof. Dr. Bohn, Aschaffenburg.

647. Apparatus for determining Vapour Density, on Dr. Frerich's system. *F. Sartorius, Göttingen.*

648. Oleometer. An instrument for ascertaining the density of oils. *Dring and Fage.*

649. Small Sykes's Hydrometer. *Dring and Fage.*

650. Barktrometer. Used by tanners for ascertaining the density of bark liquor. *Dring and Fage.*

The indication of the steam in degrees, and true specific gravity at 60 F.; the sliding rule accompanying the instrument enables indications at higher or lower temperature to be reduced to the equivalent at 60 F.

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651. Small Barktrometer. *Dring and Fage.*

The same in principle as the larger one, but it is not capable of indicating over so wide a range of specific gravities.

652. Salinometer, used on steam vessels to ascertain the amount of salt in the water in the boiler. *Dring and Fage.*

On the stem of the instrument are the words "limit" and "blow." "Limit" indicates the maximum amount of salt in the water that can be used with safety, and "blow" when it is necessary to blow off a portion of the water in the boiler through there being too much salt in solution.

653. Atkins' Saccharometer. (Obsolete.) *Dring and Fage.*

654. Four-weight Hydrometer on Sykes's principle. (Obsolete.) *Dring and Fage.*

The stem is divided into 20 parts, and a part again divided into 2 parts, each of which is equal to one-half per cent. The sliding rule accompanying this instrument gives the equivalents of other hydrometers of the same period. About 1817.

656. Sykes's (Revenue) Hydrometer. For ascertaining the proof-strength of spirits. *Dring and Fage.*

The instrument, used by the Revenue in collecting the duty on spirits, was first established under Act of Parliament in the year 1816; by this Act also proof spirit (which forms the basis of estimation in this instrument, as all strengths are indicated by their relation to this point) received a particular definition as that which weighed twelve-thirteenths of an equal bulk of distilled water at a temperature of 51° Fah. The stem of the instrument is divided into 10 parts, and each part again into subdivisions, which, with the nine weights (each of which is a multiple of the divisions of the stem), enables the instrument to measure all gravities from 67 over proof to just past distilled water at 60 Fah. The tables which accompany this instrument were compiled from the experiments of Gilpin, who carried them out with such accuracy that no error has ever been detected. The range of temperature given is from 30° to 80° Fah. These tables having been found inconvenient for use in hot climates, in the year 1851, Messrs. Dring and Fage compiled an extension from 80° to 100°, which meets all requirements for high temperatures.

657. Clark's Export Hydrometer (obsolete). Used for ascertaining the strength of spirits in the various stages of manufacture. *Dring and Fage.*

The instrument used for determining the strength of spirituous liquors prior to the introduction of Sykes's hydrometer. It was the first of its kind established under Act of Parliament, and to which any definite kind of correction for temperature was applied. It is constructed to show the number of gallons of water, plus or minus, necessary to reduce to proof strength a sample of spirits under trial, and was only used for spirits in the various stages of manufacture.

658. Clark's Import Hydrometer (obsolete). Formerly used for ascertaining the strength of spirits imported. *Dring and Fage.*

The same in principle and construction as the one for export, only having nine extra or intermediate weights, called per cent. weights. This class of instrument was only used for determining the strength of spirits imported, and was adjusted slightly in favour of the importer.

659. Set of Six Twaddell's Hydrometers. Used for ascertaining the density of a solution; principally used in trades for which no special instrument of the kind is constructed.
Dring and Fage.

The divisions on these instruments are so placed as to indicate equal differences of specific gravity. The specific gravity of a fluid is found from the indication of this scale by multiplying by 5, cutting off 3 decimal places, and prefixing unity.

659a. Hydrometer by Fordyce. *Royal Society.*

659b. Hicks's Patent Hydrometers, Urinometers, Salinometers, &c. *Hicks.*

These instruments have the scales and figures divided in black on a white enamel stem, thus avoiding all errors from shifting of scale, as with paper; alteration of form, as with vulcanite; or corrosion, as with metal.

651a. Tan Tester, for ascertaining the exact quantity of tannic acid in any substance by passing it through a piece of hide.
Thomas Christy and Co.

The solution having been gauged by a tannometer before being tested and after it has passed through the hide, the *difference* gives the exact value of any tannic matter, and a merchant knowing the price of oak bark can calculate the value at once of the substance he has tested.

655. Specific Gravity Instruments, for testing liquids from 650 to 900 sp. gr. *L. Oertling.*

659a. Fahrenheit's Metal Hydrometer.
The Physical Science Laboratory of the Technological Institute, St. Petersburg.

The theory of this instrument has been described and illustrated by an example by E. Lenz, Academician, in the "Bulletin physico-mathématique "de l'Académie des Sciences," Vol. XV., 1857.

660. Thermo-Dilatometer, by Baudin, showing by dilatation the per-centage strength of alcohol, from distilled water 0 to absolute alcohol 100. *M. Baudin, Paris.*

661. Thermo-Dilatometer, by Baudin, showing by dilatation the alcoholic strength of wines and other liquids, from 10 to 20 per cent.

(The last two instruments are the property of the "Conservatoire des Arts et Métiers.") *M. Baudin, Paris.*

662. Dring and Fage Saccharometer, for ascertaining the density of brewers' worts. *Dring and Fage.*

Used for determining the density (in pounds weight) of a barrel of wort, of 36 imperial gallons, in excess of the same quantity of distilled water at a temperature of 60° Fah. The rule accompanying the instrument shows the weight of the residuum if a barrel of wort were evaporated to dryness; also the amount of proof spirit to be obtained, and the specific gravity.

This instrument was the joint invention of Messrs. Dring and Fage, and perfected by the valuable experiments and calculation of Drs. Hope Coventry and Thomson.

663. Quin's Saccharometer. (Obsolete.)

Dring and Fage.

664. Dring and Fage Still, for ascertaining the original specific gravity of a wort from a sample of beer. *Dring and Fage.*

Used by the Excise and Customs when making the allowance for drawback on export beer.

664a. Apparatus by **Rakowitsch** for testing **Alcohols** and **Saccharine Matter** in **Liqueurs;** likewise for ascertaining the fatness of butter, and for testing water.

R. Nippe, St. Petersburg.

665. Apparatus for determining the Specific Gravity of bodies, inclusive of a thermometer.

Ch. F. Geissler & Son, Berlin.

671. Piknometer. *Dr. H. Geissler, Bonn.*

671a. Piknometer, for ascertaining the specific weight of small quantities of liquid, with thermometer attached.

W. Haak, Neuhaus, Thüringen.

672. Two Sets of Areometers. *Dr. H. Geissler, Bonn.*

672b. Micromanometer.

Royal Mining Academy, Freiburg.

672c. Drawing of Apparatus for measuring low pressures of Gas. *Prof. H. McLeod.*

The pressure is measured by compressing a known volume of the gas into a smaller space, and measuring the pressure under the new conditions. By dividing the pressure thus found by the ratio between the original volume and the reduced volume, the original pressure is obtained. *See* Proc. Phys. Soc. i. 30.

673. Manometer for Minute Observations, used by A. de la Rive in all his latest researches concerning the propagation of electricity in rarefied gases.

De la Rive Collection, the property of Messrs. Soret, Perrot, and Sarasin, Geneva.

This instrument, constructed by the Geneva Association for the Construction of Scientific Instruments, consists of two glass tubes dipped in a common mercury trough, of which one is a simple barometric tube serving as a point of comparison, the other communicating on its top with the quantity of rarefied gas by means of a pipe adjusted in the setting of the apparatus. The pressure, that is, the difference between the two mercury columns, is read by means of a small cathetometer, of which the millimetric graduation is turned towards the tubes and the lamp which lights them both. This graduation is reflected in the telescope by means of a total reflecting prism placed before the objective. Thus the level is at once read, and a micrometrical division placed at the focus of the eye-piece shows the $\frac{1}{25}$ of the millimetre.

673a. Delicate Pressure Gauge. *E. A. Cowper.*

The very light pressure required to produce a current through stoves can be shown by the delicate pressure gauge (enclosed in a mahogany case), which has a thin diaphragm exactly one square foot in area, and has a light lever and weights to cause it to bear the pressure brought on its surface, so that the whole pressure of the air on one square foot is exactly weighed with ease. As small a pressure as one hundredth of an inch of water can be measured.

673b. Multiplying Manometer, for measuring the force of the draught in chimneys and stoves, as well as for the pressure of gas. *Dr. K. List, Hagen, Westphalia.*

This apparatus was first constructed by the exhibitor in 1862 for the purpose of meeting the desire of several blast-furnace proprietors resident at Hagen, who wished to be able to measure more accurately the pressure of the blast in their furnaces than was possible with the ordinary manometer, consisting of a curved glass tube, as is mentioned in the description given in the "Zeitschrift des Vereins deutscher Ingenieure," (Journal of the Society of German Engineers) of 1863, vol. vii, p. 493. It consists essentially of a long narrow horizontal and two wider vertical glass tubes, the latter of which are filled to about half their length, and the first up to a long air-bubble, with coloured petroleum. If a suction is effected on one of the vertical tubes, the air-bubble contained in the horizontal tube must, if the vertical tube has a diameter n times as large as the horizontal tube, traverse a distance in the horizontal tube n^2 times as large as the liquid rises or falls, as the case may be, in the vertical tube; the sensibility, therefore, can be increased at pleasure. The space which the index travels is $\frac{n^2}{2}$ times as large as the difference in the respective heights of the liquid in the two vertical columns.

The apparatus has been constructed for some years by the exhibitor himself; the scale indicating in water-millimeters the difference of pressure was prepared by him in the manner described in the Journal of the Society of German Engineers. The apparatus has answered well everywhere. It has been recommended for measuring the pressure of gas by authorities such as Schiele in Frankfort-on-the-Maine and Schilling at Munich.

673c. Level Manometer, by Gallaud. *M. Breguet, Paris.*

673d. Two-fold Control Manometer.

C. D. Gäbler, Hamburg.

1. The advantage here consists in two independent manometers, acting under quite similar conditions, being combined in one case, whereby not only a greater guarantee of control is obtained, but by the close proximity of the two scales the simultaneous reading of the divisions is facilitated. The upright position of the tubes prevents the collection of impurities out of the

water, as the latter flows freely away after use. The instrument may be connected by a simple screw arrangement with the boiler.

673e. Four-fold Control Manometer.

C. D. Gäbler, Hamburg.

This manometer, consisting of two manometers of the above construction, combined one with the other, offers the greatest possible safety in controlling; because, if only two-fold action be required, the one pair of manometers can be shut off by closing the stopcock, and may thus be used as reserve or control of the manometer thence used. The connexion with the boiler flange is performed by means of the accompanying two thumb nut-screws.

673f. Control Manometer, showing the inner construction.

C. D. Gäbler, Hamburg.

Shows the extremely simple construction of the inner mechanism of the manometers described above.

674. Alcoholometer, consisting of two cylinders of ebonite and brass, keyed together. *G. Recknagel, Kaiserslautern.*

This instrument is not liable to break, and answers all requirements of accuracy in reading.

675. Areometer of ebonite and brass, with adjustable cylinder.

G. Recknagel, Kaiserslautern.

This not being liable to be broken can be used for educational purposes as well as for practical application.

The level upper terminal plate is adapted for the addition of small weights by means of which the value of the divisions can be demonstrated. The instrument, moreover, is arranged with a *cylindrical slide*, which can be extended to the double volume of the divided spindle. If the scale is overrun, the slide is to be pulled out a volume more, and the scale is then again at disposal for use.

For instruction and practice the most suitable is the uniform scale of the Gay Lussac areometer. As, however, there is space for four scales, the others can be arranged for direct indication of specific weights, or, like the present models, for alcoholometry.

676. Areometer Case, containing three standard areometer-cylinders, for determining the specific gravity of all kinds of liquids, with indicator scale fused into them. *W. Zorn, Berlin.*

677. Areometer. The indicator scale is not fused into the glass, but fastened only with sealing-wax. *W. Zorn, Berlin.*

Each of these areometer-cases contains three glass spindles, which, loaded at the top in a similar manner to Nicholson's metal spindles, with weights, indicate with the greatest accuracy the specific weight of *all* liquids.

The liquid to be tested must be brought to a temperature of 15° Celsius; if one of the spindles is inserted in the liquid, so many weights must be placed on the glass plate as are required to make the spindle sink as far as the black mark on the milk-white glass line in the neck of the spindle.

The lightest spindle embraces all liquids from 0·650 to 1,000; if this has been used, 0·650 must be added to the weight placed on the spindle. If the medium (1,000) spindle has been employed, 1,000 must be added to the weight, and at the heaviest (1,400) spindle, 1,400 must be added to the weight placed on the same. The sum obtained will give the specific weight of the liquids with an accuracy extending a little over the third decimal.

The proof of the correctness is simple; it is only necessary to have a good pair of scales and some distilled water:

650 weight = spindle 0·650;
spindle 0·650 + 350 weight = spindle 1,000;
spindle 1,000 + 400 weight = spindle 1,400.

The construction of these areometers is *new*. For many years the exhibitor had constructed similar areometers, consisting, however, of two spindles only, which were very much liked, under the name of Wittstock's areometer, on account of their accuracy; but it was too fragile, owing to the light spindle (there being but two of them) having to carry too much weight. Moreover, the late Privy Councillor, Dr. Wittstock (apothecary to the Royal Court at Berlin), had devised a peculiar proportionate weight to the same, from which the spindles had derived their name, but which is now no longer in use.

The areometers constructed by the exhibitor, the normal weight of which has been recommended by Mr. Hirsch, apothecary, at Giessen, and which corresponds to the gram scale, have the following advantages, compared with other similar instruments:

They can be easily tested as to their accuracy (as shown before); they will not be affected by the liquids; they can be easily cleaned, and will sink slowly and uniformly in any liquid, and are not surpassed, nor even equalled, by most similar instruments, in respect of accuracy.

One of the exhibited areometer-cases contains three spindles, which are perfectly equal in point of accuracy with those in the second case. The milky glass lines at the neck are, however, fastened only with sealing-wax, which, in case of great carelessness, may dissolve, although persons of experience have used these spindles for years without injury; besides, every particle of sealing-wax can be easily supplied as soon as any defect has been noticed. But, in order to avoid this, the milky glass lines on the three spindles in the second case have been melted together with the glass plate.

Besides the weights, there are added to the two cases a cylinder for weighing the liquids, a pair of forceps for placing the weights, and a thermometer for determining the temperature of the liquids, which latter is adapted in its form and the strength of the glass to be used as a stirring rod.

The exactness of the indications of Zorn's spindles affords also the advantage of testing the correctness of other liquid scales, such as Tralles, Baumé, and others made on a scientific basis.

679. Alcoholometer.

Siemens Brothers and Co., Charlottenburg.

An apparatus for measuring simultaneously the quantity of spirit flowing through it, and the per-centage of proof spirit contained in that spirit. The quantity is measured by a revolving drum imparting motion to a counter under the control of a hydrometer containing spirit such as is the average production of the still. The measurement is unaffected either by the velocity at which the spirit enters or by the friction of the bearings of the spindles of the drum.

679a. Metallic Alcoholometer, on Tralles's principle.

W. Gloukhoff, St. Petersburg.

The metallic alcoholometer, with additional weights, newly adapted by the Russian Government, is made on the principle of Sykes's hydrometer, but its scale is adapted to the system of Tralles, legalized in Russia.

VI. MISCELLANEOUS.

680. Apparatus, serving to illustrate the **Mechanical Effect** of the **Expansion** of **Liquids.** *T. A. Snyders, Delft.*

Consisting of gun-barrels closed by a lead plate 3 millimetres thick, which is retained by a perforated screw-plug. The expansion of the liquid causes a cylinder of lead to be forced out through the aperture of the plug.

681. Apparatus, constructed by **Leschot** and **Thury,** to **suppress Friction** by the interposition of a stratum of air.
Geneva Association for the Construction of Scientific Instruments.

The apparatus is composed of two plates, superposed, and perfectly adjusted, between which is introduced air or gas under pressure. The air, spreading from the centre between the two plates, exerts upon these a total pressure measured by its elastic force multiplied by the extent of the surfaces brought into apparent contact. When this pressure equals or exceeds the weight of the plate acted upon, it supports the plate, and the friction is reduced to its smallest limits.

683. Two Apparatus for measuring the Transpiration of Air at different Temperatures.
Dr. O. E. Meyer, University of Breslau.

(Described in "Poggend Ann., 1873," vol. 148, p. 203.)

684. Apparatus to illustrate to a large audience the fact that the **pressure** exerted by a **curved liquid** film increases with the curvature. *The Yorkshire College of Science.*

The apparatus consists of a glass tube communicating with two others, each of which is furnished with a stop-cock. Bubbles of different diameters are blown at the ends of the tubes, one stop-cock being closed while the other is open, and then communication with the outer air being cut off, and the cocks both opened, the smaller bubble is seen to diminish and the larger one to increase, thus proving that the air inside the smaller bubble was the more compressed. The tubes are bent, so as to bring their extremities close together, and the experiment can be shown to a large audience by throwing a magnified image of the bubbles on a screen.

685. Apparatus for demonstrating **Leidenfrost's phenomenon** of **drops.** *Dr. J. Hoogewerff, Rotterdam.*

This apparatus was constructed by Mr. Kellenbach, curator of the Batavian Society, Rotterdam, and belonging to the academy of plastic arts and technical sciences at Rotterdam. The apparatus is used as follows : a Grove pile is connected with the instrument, a galvanometer being placed on the conducting wire, and the copper tray or platinum capsule into which the drops of water have been put, are heated by means of a gas lamp. Every time Leidenfrost's experiment is repeated, no current is indicated by the galvanometer, contact having been interrupted by the layer of steam ; when on the contrary the water, the surface of which is in contact with the copper wire, comes into immediate contact again with the metallic surface of the tray or capsule, the galvanometer distinctly indicates the current.

686. **Apparatus** for determining the **Tension** of the **Vapours** of different liquids at the boiling point.

Prof. W. F. Barrett.

This is a useful and strong form of the usual apparatus. The liquids whose tensions are to be measured are inserted in the barometer tubes, and either steam or the vapour of some liquid having a lower boiling point, such as alcohol, is sent through the larger tubes.

670. **Parabolic Diagram** of the relation between tension and volume of the saturated steam.

H. Hädicke, Demmin, Pomerania.

The area of this parabolic tension diagram shows that it is justifiable to replace the area of Mariotte's oder Pambour-Navier's tension-lines of the saturated steam by a parabola. This method gives for the ratio of the mean pressure (p_0) on one side of the piston to the absolute pressure at the commencement (p), and the cut off (ϵ) the elementary formula : $p_0 = p - \frac{1}{6}(1 - \epsilon)^2(4p + 1)$, or

$$\epsilon = 1 - \sqrt{\frac{6(p - p_0)}{4p + 1}}.$$

(See "Practical Tables and Rules for Steam Engines," by H. Haedicke Kiel, 1871.)

687a. **Independent Bed Plate** for **Pneumatic Machines.**

Geneva Association for the Construction of Scientific Instruments.

This plate is made entirely of cast-iron, as well as its stand, so as not to become damaged in experiments where mercury is employed.

SECTION 6.—SOUND.

WEST GALLERY, UPPER FLOOR, ROOM (Q).

I.—SOURCES.

688. Apparatus used by M. Rijke to cause a tube to emit sounds when wire gauze placed in its interior is heated.
Prof. Dr. P. L. Rijke, Leyden.

689. Whistles for producing shrill notes, within and beyond the limits of ordinary audition. *Francis Galton, F.R.S.*

These whistles were designed for testing the limits of the power of men and animals of hearing very shrill notes. The plugs that close the whistles can be screwed up and down, and the length of the whistle can be ascertained by the attached graduations, whence the number of vibrations per second may be calculated. The whistles are of three forms : (1) a small cylindrical tube, which gives a pure note, but of small power ; (2) a flat, wide and narrow whistle, of which the plug is a broad thin plate of metal ; (3) an instrument which is externally a cylinder of 2½ inches in diameter, but of which the effective part is merely an annulus ; the plug of this is a cylindrical sheet of brass ; it gives a powerful note, but not a pure one.

690. Brass Tube to sound the constant proper tone of the mouth, characterising the vocal sound.
Prof. Donders, Utrecht.

This consists of a brass tube terminating in a broad slit at one end and at the other end in an india-rubber tube to be placed on a blower ("*souffleur*"). (Donders.) The blast, directed by the slit on the borders of the lips, sounds during the time a vocal sound is sung in different tones, the constant proper tone of the mouth characterising the vocal sound. (Compare Donders, Uber die Natur der Vocale, Holl. Beit. zur Nat. u. Heilk. 1846.)

691. Set of Vowel Forks and Resonance Globes.
Frederick Guthrie.

692. Set of Organ Pipes. *Frederick Guthrie.*

693. Set of Tuning Forks. *Frederick Guthrie.*

926o. Acoustical Instrument, illustrating harmony and discord. *S. F. Pichler.*

This instrument is constructed to demonstrate the relations between musical sounds. By its means, harmony and discord, gravity and acuteness of pitch, beats, waves, and amplitude of notes, may be rendered visible as well as audible.

Two metallic vibrators, each with a small speculum, are fixed at right angles to each other, and sounds are produced by a current of air acting on one or both of them at pleasure. The perpendicular vibrator is tuned to a given note, and the horizontal vibrator is fitted with a mechanical arrangement, whereby its pitch can be graduated to any degree of nicety within the compass of two octaves. An apparatus is also provided with a means of concentrating a pencil of light upon the speculum of the perpendicular vibrator, whence it is reflected to the speculum of the horizontal vibrator. For educational purposes, artificial light may be used, which can be further reflected and magnified upon a screen so as to be visible to a number of spectators.

When musical sounds are produced by the vibrations, various luminous geometrical figures are formed on the horizontal speculum, which, being thence thrown on the screen give the curves described by the pencil of light, by the single or joint action of the vibrators, and the form and motion of such figures demonstrate the exact relation to each other of the musical notes produced.

Sounds which harmonise to the ear, produce regular figures to the eye, as for example, segments of the circle, ellipses, ovals, or straight lines, and if the amplitude of each vibrator be equal, these luminous figures will appear on the speculum or screen with an apparent steadiness. If the sounds do not harmonise, the figures are confused, unsteady, and complicated.

The mathematical relations of musical notes can also be demonstrated by this instrument; regular simple forms being produced by combinations of those notes which result from vibrations bearing a definite numerical ratio to each other, while irregular and unsteady figures are caused by notes which have no such ratios.

This apparatus has advantages over those in which tuning forks are used for a like purpose; (1.) In being able to prolong the effects to any period desired by the operator; and (2.) In its capability of representing combinations and graduations otherwise unattainable.

694. Photograph of a Chemical Harmonica of glass for gas-flames, with eight pipes (major-scale from d^1 to d^2 inclusive), with double regulating cocks, and key-board for playing. With a copy of a few melodies executed on the same for two and three voices.

Prof. J. Joseph Oppel, Frankfort-on-the-Maine.

The glass tubes can be turned by means of metal mountings, and can be adjusted according to the height of the flames, which being regulated by the taps, and the acoustic effect of the major and minor accords (particularly when carefully tuned) are astonishing.

695. Diapason Tuning Fork. *F. Ernecke, Berlin.*

695a. Diapason of 200 double vibrations, arranged for continuous action. *T. Hawksley.*

695b. Model of a Scientific and Musical Instrument called the Pyrophone, invented by the exhibitor, composed of a series of glass tubes of different lengths and dimensions, in which gas jets, when ignited and moved by a very simple apparatus, produce the most perfect musical notes, and establish the new scientific principle of the "interference" of melodious flames.

Frédéric Kastner, 43, Rue de Clichy, Paris.

The great pyrophone, which this model represents, has three octaves, like those of a piano, and is composed of a series of glass tubes, similar to organ pipes, of different lengths and dimensions, in which gas jets burn. A very simple mechanism causes each key to communicate with the corresponding supply pipe of the flames in the glass tubes. On pressing the keys, the flames separate and the sound is produced as soon as the little jets in each tube are separated from each other; when re-united and becoming one flame, the sound immediately ceases.

In this instrument it is shown that when two or more flames are introduced in a tube they vibrate in unison, and produce a musical sound when they are placed one-third the length of the tube, and a new law has been demonstrated, as an application of which an instrument which approaches the human voice more nearly than any yet made has been constructed.

A contrivance opens and shuts like the fingers of a hand, at the extremities of each of which a small jet of gas is lighted. When the fingers are separated, the sound is produced; when they are closed or approach each other, the sound ceases, and the numerous jets become one silent flame.

The new principle is as follows :—" If two or more flames of a certain size " be introduced into a tube made of glass or other material, and if they be " so placed that they reach to the third part of the tube's height (measured " from the base), the flames will vibrate in unison. This phenomenon con" tinues as long as the flames remain apart, but as soon as they are united the " sound ceases."

The pyrophone gives sonorous and penetrating tones, and may be constructed from one octave to a most extended compass, and for the *cabinets de physique*, with one, two, three, or more notes to show the principle of the " interference " of singing flames. The exhibitor has also invented a gaselier (*lustre chantant*), lighted by electricity, which can be placed in the centre of a room, and by unseen electric wires be made to produce powerful and melodious sounds, and on which any kind of music can be performed.

696. Tube for Singing Flames, according to Schaffgotsch's system. *Albrecht, Tübingen.*

697. Set of Glass Tubes for illustrating singing flames, with paper sliders for adjusting the pitch of any tube.
Prof. W. F. Barrett.

The only novelty here is the paper sliders, which enable the pitch of the note to be readily adjusted, and were originally suggested by the exhibitor.

697a. Stand and Burner for Sensitive Flames.
Prof. W. F. Barrett.

The sensitive flame is an illustration of resonance. The vibrations accepted by the flame are those which the flame itself would emit when roaring. A flame to be sensitive must be brought to the verge of roaring by a proper adjustment of pressure on the gas supply. The flame is then in unstable equilibrium, and a feeble sympathetic vibration will then produce the same effect on the flame as a slight increase in the gas pressure.

The flame to be extremely sensitive must be fed with gas which flows smoothly and freely to the orifice. A bell gas holder is far better than a gas bag for obtaining the necessary pressure. The gas cocks must be fully open and the pressure adjusted by altering the weights on the gasholder. The stand shown allows the gas to flow smoothly, and the best burner is a steatite "jet photometer" burner carefully enlarged till it gives the *tallest possible* flame under a pressure just short of roaring. Such a flame with good gas can be had 2 feet high, shrinking down under the influence of a sound to less than one half this height. With similar burners and pressures the quality of different specimens of coal gas is accurately determined by the degree of sensitiveness of the flame. See Phil. Mag., March and April 1867.

697b. Suitable source of Sound for experiments with Sensitive Flames. *Prof. W. F. Barrett.*

This is simply a loud ticking watch enclosed in a padded case with a movable cover, and mounted on a sliding stand.

697c. Practical application of Sensitive Flames. *Prof. W. F. Barrett.*

By using a suitable burner a sensitive flame can be made to spread out sideways into a fish-tail flame under the influence of sound. Under such conditions the flame can be made to touch a compound metallic ribbon, which curves by unequal expansion, closes an electric circuit, and rings an electric bell. An arrangement of this kind could be adapted to detect burglars, or to act as a self-recording phonoscope. First exhibited by Prof. Barrett at the Royal Dublin Society, January 1868.

698. Set of Resonant Tubes. *Prof. W. F. Barrett.*

By suddenly and successively withdrawing the stopper, the resonance of the air within the series of tubes will give the notes of the common chord.

699. Apparatus for experiments with singing gas flames. *Yeates & Sons.*

The above, consisting of glass tubes of similar size, with the assistance of a revolving mirror, will illustrate most of the phenomena of interference, harmony, &c.

700. Inferior Limits of Audibility. An apparatus to show the lowest number of vibrations that will produce sound. *Elliott Brothers.*

701. Sir Charles Wheatstone's Resonating Tube. *W. Groves.*

By moving a piston up and down, and thus diminishing or enlarging the resonator, a perfect two-octave scale of aliquot parts may be produced from a spring, which would otherwise sound but one note. The scale may thus be played as rapidly as by the fingers upon a pianoforte. Set the spring in vibration by a twang with the forefinger of the left hand, and draw the piston with the right hand.

701a. Sir Charles Wheatstone's original "Magic Lyre," for rendering vibrations audible at a distance through wires. *Robert Sabine.*

704. Set of five Steel Tuning-forks on a new system. *Dr. Stone.*

II.—MEASUREMENT.

705a. Apparatus, by M. Regnault, for ascertaining the velocity of sound. *College of France, Paris.*

706. Acoustic Apparatus, for ascertaining the velocity of transmission of sound through water, used in 1826 on the Lake of Geneva at a distance of 13,487 metres, and subsequently in 1841 at a distance of 35,000 metres.

Prof. Daniel Colladon, Geneva.

This apparatus was used in 1826 and 1841, during a series of experiments upon the transmission of sound through water, and upon the direct measurement of the velocity of sound in the water of the Lake of Geneva.

Mémoires de l'Académie des Sciences de l'Institut de France, savants étrangers, sciences mathématiques et physiques, vol. 5, p. 267 and following pages. Comptes-rendus de l'Institut, vol. 13, p. 439, séance 23rd August 1841.

N.B.—With this instrument it is possible in calm weather to hear, at the distance of more than a hundred kilometres, the blows struck upon a bell of about half a ton weight immersed in the water, which may thus be used as a submarine telegraph, or for transmitting signals in foggy weather.

715. M. Le Roux's Apparatus, for determining the velocity of sound. *Conservatoire des Arts et Métiers, Paris.*

707. Apparatus for registering Tuning-fork Vibrations. *Prof. L. von Babo, Freiburg, Breisgau.*

707a. Original Apparatus, by Duhamel, for registering vibrations. *Polytechnic School, Paris.*

708. Helmholtz' Double Siren.

H. Lloyd, Trinity College, Dublin.

705. Revolving Drum, for determining pitch of note.

Frederick Guthrie.

The styles attached to two vibrating forks mark sinuosities on the blackened surface of the drum when it turns and advances on its screw axis. The pitch of the notes is thus compared.

709. Double Siren, such as was employed by Professor Helmholtz in his researches on sound.

Frederick Guthrie.

710. Siren, of card-board, with four circles of holes, 64, 80, 96, and 128, giving major chord. Made by Yeates and Sons.

Prof. W. F. Barrett.

The above is provided with an air-chest and four keys, so that any or all the circles of holes can be made to sound at pleasure.

711. Siren, an instrument for showing the number of vibrations corresponding to a given note. *Elliott Brothers.*

712. Savart's Toothed Wheels. A set of wheels, of different sizes and numbers of teeth, to produce a succession of notes. *Elliott Brothers.*

713. Sonometer, with sound-post on the principle of the violin. Also adapted for passing the galvanic current through strained wires. *Dr. Stone.*

714. Metronome, invented by Francis Wollaston. *G. H. Wollaston.*

716. Phonometer. *Prof. Lucae, Berlin.*

The phonometer, "speech-measure," is intended to determine accurately the intensity of speech, that is to say, the pressure of expiration employed in speaking.

The apparatus consists of a short metal tube, one end of which expands in the shape of a funnel to a kind of mouth-piece, the rim of which is coated with india-rubba. The other end of the tube is attached to a contact lever oscillating in an axis, the lower section of which is formed by a round aluminium plate, which closes the tube when the lever is in a vertical position and in repose, whilst the upper end of the contact lever, terminating in a point, indicates on a quadrant the oscillations of the pendulum. By any word which is spoken into the mouth-piece, the plate will be pressed outwards according to the pressure of the air employed. When speaking is discontinued a spiral spring attached to the axis has the effect of suspending the action of the lever at the maximum of the motion transmitted to it, and its inclination can be read on the quadrant. The practical use of the instrument in the first instance is, to determine when speaking in a loud or a low voice the relative intensity of one and the same word, or, rather, the preponderating sound prominent in the word uttered, and imparting to it the greatest colour. This object the apparatus perfectly accomplishes, since the force of utterance is proportional to the density of the air effected in the tube. The apparatus consequently affords, among other things, a more exact test of hearing with persons slow of hearing than has been the case hitherto with ordinary speaking.

716a. Phonoptometre, by M. Lissajous. *M. J. Duboscq, Paris.*

716b. Experimental Windchests, for measuring the effect of heat on reeds. *Dr. Stone.*

III.—ANALYSIS AND SYNTHESIS.

717. Series of Chladni's Figures. *Frederick Guthrie.*

Sand being scattered on a square brass plate, clamped in the middle and horizontal, the plate is bowed at various points of its edge, while various other points are touched with the finger. The sand is accumulated in the lines of least motion or nodal lines. Gummed paper is then pressed upon the figures so formed.

718. Five Wire Figures for representing **Lissajous' Figures.** *Prof. Buys-Ballot, Utrecht.*

On a horizontal wooden rod are placed five figures of wire, so bent that their shadows or lens images form the figures of Lissajous. Each interval has its own wire figure, and the changes produced by various phase-differences are shown by turning the figures round their vertical axes.

719. Wooden Board for constructing **Lissajous' Figures.** *Prof. Buys-Ballot, Utrecht.*

The instrument consists of a white-painted wooden board, on which a circle is traced. Horizontal and vertical lines cut the circle in points corresponding to the angles of a regular inscribed icosagon. At the intersection of each pair of lines a hole is made in the board for fixing pins, which can be joined by threads for showing the figure. Along one of the horizontal and vertical sides of the board two rods can be fixed, provided with ciphers corresponding with the horizontal and vertical lines. Each of these lines may be figured to represent the phase of a vibrating particle either by sound or light for each twentieth part of a vertical and horizontal direction.

For instance, the figure exhibited by the interference of two notes of the same pitch is constructed in the following manner:—The horizontal rod indicates the vertical chords on which the particle is at a supposed moment by a horizontal vibration, then the perpendicular rod indicates in the same manner the horizontal on which it would be at the same moment by a vertical vibration. By fixing pins at the intersections of those chords indicated by the same ciphers, and joining them by a thread, the desired figure originated by both motions is obtained.

If the oscillations differ in phase, another rod not beginning with the same cipher, but with another differing as many twentieth parts of the oscillation as required is found.

If the two interfering notes are not of the same pitch, but one figure is the octave of the other, for the higher note a difference of phase double as great as for the other is taken, and so on.

719a. Tonophant, a simple arrangement for showing **Lissajous' Figures.** *See* Phil. Mag., Sept. 1868.

Prof. W. F. Barrett.

719b. Apparatus for exhibiting the **combination of rectangular Vibrations,** made by Yeates & Son, Dublin.

Prof. W. F. Barrett.

By turning the handle the two mirrors have a vibratory motion imparted to them in planes at right angles to each other; the relative rate of vibration of the mirrors can be adjusted by a simple mechanical contrivance. A beam of light reflected from one mirror to the other and projected on a screen thus enables a large audience to see the whole of Lissajous' figures.

1576a. Wheatstone Kaleidophone.

The British Telegraph Manufactory, Limited.

1576b. Wheatstone Kaleidophone.

The British Telegraph Manufactory, Limited.

720. Melde's Universal Kaleidophon.

Ferdinand Süss, Marburg.

(*See* Poggendorff's Annalen, vol. 114, p. 117.)

This apparatus is too well known already to require in this place a more detailed description as regards its capabilities. It will therefore be necessary to give only a short explanation of the reading indications on the Lamellæ, and to refer, as to all specialities respecting this apparatus, to Prof. Melde's publications. Poggendorff's Annalen, Vol. CXIV., page 117, "Lehre von den Schwingungs-Curven," by Dr. Franz Melde, p. 25.

The great Lamella has on each side a line as a mark, and on its upper end the figures I. and II.; the smaller Lamellæ have the same figures I. and II., and on each side three lines.

If the great Lamella is placed upon the mark of side I., and the small Lamella on the line of side I., with the indication $\frac{1}{4}$, then the vibrations of both Lamellæ to each other are as 1 : 4. The indications of side II. naturally correspond to the mark of side II. on the great Lamella.

The Lamella with the little mirror is used when the curves are to be shown to a whole audience, for which purpose the apparatus ought to be so placed that the rays of the sun, or electric light, falling on the mirror are thrown either on the ceiling or on the wall of the room.

The round bars serve for the production of oscillating curves of two elliptical vibrations.

Finally, it is to be observed that the apparatus may be used equally well for fixing the vibration curves, for which purpose a phonautograph is employed, the cylinder of which is covered with a paper, *as smooth as possible*, on which soot is lightly scattered.

A small piece of the top of a feather fastened with wax upon one of the smaller Lamellæ will be sufficient to describe the curves. In this case, the oscillating surfaces ought to be parallel.

721. Atlas, belonging to the same, illustrative of the theory of oscillation curves, by Dr. F. Melde.

Ferdinand Süss, Marburg.

722. Melde's Tuning-fork Apparatus for producing stationary waves on a thread.

(*See* Poggendorff's Annalen, vol. 109, p. 193; and vol. 111, p. 513.) *Ferdinand Süss, Marburg.*

In Poggendorff's Annalen, Vol. CIX., p. 193, and Vol. CXI., p. 513, a detailed description is given of this apparatus, and of several experiments made with it; also an account of the theory of the oscillation curves ("Lehre von "den Schwingungscurven"), by Dr. Franz Melde, p. 94.

By means of the small sliding rod of glass which is screwed into one of the prongs of the fork, and rubbed with wet fingers, the tuning-fork is brought into a state of vibration. (The small glass rod, owing to its fragility, must be inserted reversely into the wooden frame, when not used, so that only the brass neck of it is visible.) On the lower part of the tuning-fork there is a peg for tuning, which takes up one end of the thread, and serves for stretching it. From this point the thread passes through the neck of the other prong of the fork to a clamp admitting of adjustment to any point of the bar, which is about a meter in length, and thus allows of any length of the thread up to this limit. In order to read the length of the thread, there is on one of the narrow sides of the bar a division indicating half centimeters.

The tuning-fork can be turned about its vertical axis in such a way that its surface of oscillation falls in a parallel line with the longitudinal direction of the thread, perpendicular to it, or at any other selected angle.

The bar can be turned about a horizontal axis, and arrested in any desired position by means of the set screw fixed at the back, so that the thread makes any desired angle with the longitudinal axis of the tuning-fork.

It requires but little practice to effect such a tension of the thread that the required number of waves always appears.

723. Melde's Apparatus for the Combination of Two Thread-vibrations.

(*See* Melde's Lehre von den Schwingungscurven, p. 99.)

Ferdinand Süss, Marburg.

723a. Melde's Apparatus for the production of Oscillation Curves of two Rectilinear Vibrations on a Strained Thread.

Ferdinand Süss, Marburg.

The apparatus consists of two principal parts, one of which is a Lamella, oscillating vertically, fastened on a pedestal, and which is set in oscillation by an electro-magnet. The Lamella itself forms the interference. The other part consists also of a Lamella, which is brought into vibration by an electro-magnet, and the surface of vibration of which can be placed at any desired angle to that of the first Lamella.

In order to put the apparatus in motion for experiments both parts must be firmly fastened, either to a long, or on two separate solid tables, at such a distance (about 8–12 feet) from each other that the thread when strained measures 3 to 3·5 meters in length. (The thread can, of course, be shortened at pleasure, or replaced by one a few meters longer; but for class experiments the length stated appeared to be most practical.) The thread is fastened to Lamella I., and passed through the hole in Lamella II. towards the peg by which the correct tension is effected.

The white points on the (red) thread serve for facilitating the better observation of the curves, and, in order to render them more prominent, the black screen is placed behind the oscillating thread. The screen has on one side small holes, which are hinged in the hooks of the frame of Lamella I.; when the screen is expanded, the foot of it is screwed firmly by a vice-pin to the opposite table.

Two (large-sized) chrome elements, the strength of which may be easily regulated, will serve best as electro-motors. In the present case two chrome elements were employed, each with two carbon plates, and a zinc plate, of 18 cm. in height, and 6 cm. in width, joined together one behind the other.

When newly charged, it was only necessary to dip the zinc plate from 1 to 1·5 cm. into the acid, in order to obtain the requisite strength of electric current. Both elements and the wire spirals of both magnets are, of course, united to form *one circuit*. As already observed, Lamella I. serves at the same time for interference, for which purpose an attachment screw is fixed at its reverse end, which is intended to be connected with the wire leading to the battery. To the attachment screw, which is in connexion with the mercury bowl, a wire is fastened, which is to be connected with the first attachment screw of the wire spirals, if the proportion of the numbers of the vibrations of the two Lamellæ are from 1:1 to 1:2 (accord, octave). If Lamella II. is to perform three or four vibrations in the same time in which Lamella I. makes only one vibration, then only one wire spindle of Lamella I. is set in motion by fastening the wire coming from the mercury bowl in the centre attachment screw. The current must always be so powerful that the interference, whose rough displacement is effected by raising and lowering the platinum pin, and the more minute displacement by turning the mercury bowl, can be so placed that the shutting off of the current is effected as quickly as possible, as upon this the purity of the figures chiefly depends.

The intensity of the vibrations on Lamella I. is regulated by raising and lowering the electro-magnet, which is kept in its position by a set screw, and on Lamella II. by screwing in and out the iron cores, and by the shifting the whole magnet.

With a powerful current the vibrations will be most regular when the magnet is entirely moved back, and the cores are screwed so closely to the Lamella that the contact just ceases.

Lamella I. has only one mark on which it always remains accurately adjusted. If it is required that it should oscillate uniformly with Lamella II. the latter is moved to the back, marked with the annotation $\frac{1}{1}\alpha\frac{1}{2}$ and upon the spot marked with × the weight is placed with the annotation $\frac{1}{1}$. If the weight is removed further from Lamella II. the oscillations of the two Lamellae are as 1: 2. If Lamella II. is moved to the mark indicated by $\frac{1}{3}\alpha\frac{1}{4}$ the oscillations of both Lamellæ are as 1:3 (S fifth of the octave). By placing the weight with the annotation $\frac{1}{4}$ upon the spct indicated with × on Lamella I. the oscillations are as 1: 4 (double octaves).

The two smaller weights of different size serve for the more exact regulation in case great changes in the temperature, or simultaneous oscillation of either one or the other of the tables, should be of injurious influence.

Lamella II., as has been observed at the commencement, can be turned about an horizontal axis, so that its vibrations can be adjusted either rectangularly, parallel, or in any angle whatever to Lamella I. In case it is necessary to ease and screw fast the hexagonal nut, the key is added for the purpose. The small key is for unscrewing and fastening the screws which fix the Lamella.

724. Melde's Wave Apparatus, for showing the production of Chladni's figures of sound, according to the theory of Wheatstone.

(*See* Poggendorff's Annalen, Jubelband, p. 101, and the accompanying description.) *Ferdinand Süss, Marburg.*

This apparatus has been more particularly described by Professor Melde, in Poggendorff's Annalen, Jubelband, page 101.

The present apparatus is distinguished by several differences from that described in the above-mentioned work, by which the manipulation is considerably facilitated, but before entering into this, it must be mentioned that in the construction of this apparatus it was kept in view that two systems of waves of equal length and equa intensity pass swiftly through a square plate.

The upper system of waves is formed of 33 rows of 17 pins each, which together make two wave lengths. The saddle upon which the pins are placed corresponds to a length of 1·5 of wave lengths; it has on two sides (above and below) wave-systems, which in so far differ from one another, as the one is like a system of two mountains with one valley in the middle, and the other like two valleys intersected by a mountain. On the longitudinal sides of this saddle rectangular zinc plates have been screwed, which are provided with divisions for adjusting the desired phases.

O denotes the centre position (middle between mountain and valley). The lines marked on the black board correspond to the waves formed by the pins. The longitudinal line serves as index upon which the lines of the saddle are indicated.

When the saddle has been adjusted in the desired position, the board is lifted by the handles fastened on the sides—as far as possible perpendicularly—

so high, that the wires running parallel under the board catch into the hooks, and so prevent the board from descending.

In order to let the board and the saddle down again, a slight pressure with the thumb on the pegs protruding from the board next to the handles, while holding the handles themselves firmly in their position, will be sufficient to prevent the too rapid, or sideways, sliding down of the board.

Finally, it is to be observed, that this apparatus can also very well replace Eisenrohr's Interference Apparatus in so far as two waves will be sufficient; it would only be necessary to add a number of bars, or if entire surfaces are desired, some saddles, the waves of which are of different and certain lengths.

Great care is required by placing the one part of the apparatus upon the other.

725. Wave Disc, by Professor J. Müller.

J. Wilhelm Albert, Frankfort-on-the-Maine.

The wave-disc by *Prof. Dr. Joh. Müller*, Freiburg (Breisgau), is an adaptation of the well-known stereoscopic disc (Phenakistoscope, or Wunderscheibe), for demonstrating the wave undulation. The eight drawings are for the purpose of illustrating the water, rope, sound, and air waves, in covered as well as in open pipes.

See "Lehrbuch der Physik," VII. Edit. Vol. I., § 155).

726. Telephon, on Reis' system, for the reproduction of sounds by galvanism.

J. Wilhelm Albert, Frankfort-on-the-Maine.

The telephon is based on the experiments of Wertheim and others regarding galvanic sounds. *Philipp Reis*, at Friedrichsdorf, made use of these with a view of reproducing by means of galvanic action the musical sounds produced by singing (or by pipes, &c. played upon), by employing an elastic membrane and an interference apparatus constructed by him.

(*See* Jahresbericht des physikalischen Vereins zu Frankfurt a Main. Jahrgang 1860–61 ; also, "Müller's Lehrbuch der Physik, VII. edit. Vol. II., § 135.

727. Crank Apparatus, for showing the production of progressive waves in water, &c.

Prof. J. Joseph Oppel, Frankfort-on-the-Maine.

The rotating liquid molecules are represented by white wooden balls on a black background, and are all put into motion by a crank attached at the back.

The whole shows two wave lengths.

728. Cylinder Apparatus, for showing directly and comparatively, progressive and stationary waves of sound, and the essential difference between them.

Prof. J. Joseph Oppel, Frankfort-on-the-Maine.

Contains 1½ corresponding wave lengths on both cylinders. Other drawings likewise, for example, with different wave lengths (for illustrating the musical intervals, &c.), can be mounted on the cylinders, which are of a somewhat conical shape.

729. Two Wave Discs of paste-board for stroboscopic illustration of a progressive and a stationary (water) wave.

Prof. J. Joseph Oppel, Frankfort-on-the-Maine.

Would be best fastened to a rotatory apparatus such as are used for colour spindles, &c., and placed in front of a mirror. All waves, with the exception of a horizontal one, should be covered by a black screen.

730. Brass Tube, with Gas-burner, for Intonation. (Compare Poggendorff's Annalen, vol. 129, 1866.)

Albrecht, Tübingen.

731. Rotating Mirror, movable towards all sides.

Albrecht, Tübingen.

This mirror has not yet been described, but several specimens have already been executed by Mr. Albrecht. That position of the mirror in which its normal forms a moderate angle with the rotatory axis, is peculiarly adapted to change the reflected image of the sonorous flame into a beautiful elliptical crown.

731a. Barlow's Logograph, an instrument for recording pneumatic effects of speech, showing the consonant actions and the vibratory effects accompanying vowel sounds.

W. H. Barlow, F.R.S.

731b. Apparatus for Synthesis of Vowel Sounds.

Prof. Clifton, F.R.S.

732. Apparatus for the projection on the screen of the curves produced by the combination of rectangular vibrations.

Yeates & Sons.

787a. Electro-Diapasons, showing the composition of vibratory movements by producing fixed acoustic figures.

M. Mercadier, Paris.

IV.—INTERFERENCE.

733. Apparatus for demonstrating, by the aid of flames, the interference of two musical sounds.

Prof. Dr. R. A. Mees, Director of the Physical Laboratory of the University of Groningen.

The apparatus consists of two curved movable cross tubes, narrowed at one end; their narrow openings, being near each other, are tightly fixed in a longer tube, also ending in a narrow opening; this is placed close to a strong flame, and also a very small flame, which can be seen in a rotating mirror. A small movable burner for this small flame is attached to the apparatus. When a sound-wave proceeds from the opening of the instrument, the strong flame diminishes abruptly in length and begins to roar, while the small flame rapidly vibrates, its motion being visible in the rotating mirror. The open ends of the two curved tubes can be placed before the mouths of two unisonant organ pipes, or above two different segments of a vibrating plate. When only one of the pipes is sounded, the flames show the vibrations, but, when both pipes are sounded, there is no agitation of the flames, the two sound-waves counteracting each other. When the two openings are above segments of the plate, which are in the same phase of vibration, the flame is agitated, but, when they are above segments in the opposite phase, the flame remains at rest.

734. Apparatus, of simple character, for demonstrating by the aid of flames the interference of two musical sounds.

Prof. Dr. R. A. Mees, Director of the Physical Laboratory of the University of Groningen.

This apparatus is designed for the same purpose as that last described, but is of more simple construction.

735. Quincke's Interference Tube, to demonstrate by the action of a flame the diminution and increase of sound by interference.

Prof. Dr. R. A. Mees, Director of the Physical Laboratory of the University of Groningen.

This apparatus is furnished with a supplementary brass tube having a narrow opening. It can be used with the same flames as those provided for the instruments last described.

735a. Interference Apparatus, by Jamin.

M. J. Duboscq, Paris.

735b. Interference Apparatus. *Prof. W. F. Barrett.*

This is a circular modification of the usual trombone apparatus. When used with a pitch pipe, the extinction of the sound is made evident to a large audience, the two resonant columns being rendered in opposite phases by adjustment of the movable circular tube.—Phil. Mag., Aug. 1874.

V.—ABSORPTION, REFLECTION, AND REFRACTION.

736. Apparatus for showing Approach caused by Vibration. *Frederick Guthrie.*

A suspended card or mass of cotton wool, or an air ball floating in water, approaches a resonant fork; and the latter, when free to move, is also urged towards neighbouring matter.

737. Apparatus for showing the Expansion of Gases by Sound. *Frederick Guthrie.*

One prong of a tuning fork is enclosed, air-tight, in a glass tube provided with a capillary exit tube, in which water stands at a certain height. On bowing the free prong of the fork the water level is seen to fall about a quarter of an inch.

738. Apparatus for the Reflection of Sound by heated air and vapours. *Prof. Tyndall, F.R.S.*

Sound of high pitch from a vibrating reed is passed through a long rectangular chamber, and caused to agitate a sensitive flame. Air, saturated with the vapour of a volatile liquid, is gently driven through six narrow openings into the chamber, at right angles to the direction of the sound. The atmosphere within the chamber is thus immediately rendered heterogeneous, and the sound waves being reflected, the agitated flame is rapidly stilled. The removal of the heterogeneous medium instantly restores the flame to its former agitation.

For the action of heated air, the rectangular chamber is turned upside down upon its support, and the heated air from six gas jets allowed to stream in through six narrow openings across the sound waves. The air thus rendered heterogeneous has the effect of immediately rendering the sensitive flame quiescent.—Phil. Trans., 1874.

739. Diagrams and Apparatus illustrating the reflection and refraction of sound-bearing waves, as exhibited to a class by means of a sensitive flame. *Prof. W. F. Barrett.*

The arrangement shows a suitable source of sound, a good form of gas pillar for yielding a tranquil flow of gas to the burner, and the best shape and size of steatite burner for the flame, together with a useful form of gasholder for giving steady pressure of gas larger than that usually given by the street mains.

These experiments were first shown by the exhibitor in connexion with a paper read by him before the Royal Dublin Society in Jan. 1868. See Quarterly Journal of Science, Jan. 1870.

VI.—RESONATORS.

740. Resonator of adjustable pitch. *Lord Rayleigh.*

Resonator, whose pitch can be rapidly adjusted to the various notes of a harmonic scale—A♭, a♭, e♭, a′♭, e″. The smallest hole is made first and adjusted until the resonator responds a♭. The second hole is then made and adjusted, until, *with both holes open*, the note is e♭. Similarly with three holes the note is a′♭, and with four holes e″. When the note A♭ is sounded on the piano or harmonium, and the resonator is suitably fingered, the various overtones are heard with great distinctness, and the phenomenon is more marked than usual in consequence of the contrast afforded by the rapid transition.

740a. Sonorous Tubes, by Dulong.
Polytechnic School, Paris.

741. Six Resonators of glazed cardboard, for the sounds: c′ (256 vibrations), e′ (320 vibrations), g′ (384 vibrations), c″ (512 vibrations), e″ (640 vibrations), g″ (768 vibrations).
Gustav Schubring, Erfurt.

VII.—MUSICAL INSTRUMENTS.

742. Enharmonic Harmonium, with generalised keyboard; 84 keys in each octave; compass, 4½ octaves.
R. H. M. Bosanquet.

This instrument is tuned according to the division of the octave into 53 equal intervals, a system sensibly identical with a system of perfect fifths.

References.—Proceedings Royal Soc. XXIII. 390.
Philosophical Magazine, XLVIII. 507, L. 164.
Proceedings of the Musical Association, 1874–5.
Novello's Dictionary of Musical Terms, Article Temperament.
Ellis's Helmholtz, pp. 692–699.
Elementary Treatise on Temperament; Macmillan, 1876.

742a. General Thompson's Enharmonic Organ. Built by Messrs. Robson, London, 1856. *John Curwen.*

It is an improvement upon a similar instrument he exhibited in Hyde Park, in 1851, which also was an improvement on the first organ built for him in 1834. It is capable of being played in 21 keys, with their minors of the same tonic. The organ is fully described in General Thompson's pamphlet, "The principles and practice of just intonation with a view to the abolition of temperament." Effingham Wilson, Royal Exchange. On the middle finger-board the keys of C, G, D, A, E, B, with their minors, can be played perfectly; on the lowest finger-board there can be played, besides the keys of C and G, those of F, B♭, acute E♭, acute A♭, and D♭. The fingering is mainly the same as in other instruments. The red shows the principal key tone of the board. The black shows the fourth and sixth of that scale, as well as the grave second, with which they make a true chord. The white shows the fifth and seventh of the scale, as well as the acute second of the same scale, with which they accord truly. The small oblong quarrils and the flutals (finger keys of a flute) are always a komma shriller or deeper than the digital in which they are embedded. The buttons are always a diatonic semitone deeper or shriller than the adjacent digital. The serrated edges are for the blind.

742b. Harmonium, with double key-board.

M. Guéroult, Paris.

This instrument, of which the two key-boards are tuned in fifths, has a *comma* at $\frac{81}{80}$ interval one from the other, which serves to verify the theories of musicians and natural philosophers upon the melodic or harmonic gamut.

743. Patent Double Trumpet, called Bi-Clairon.

Franz Hirschberg, Breslau.

The double trumpet (Bi-Clairon), constructed by the exhibitor, is described by him equally as an interesting and practical invention. As the instrument consists of two bell-mouths of different measure and construction, into which the air can be admitted or from which excluded at pleasure through the valve, it has been rendered possible to produce by the same two kinds of sounds, which, according to their sonorous colour, are equal to at one time the bugle horn, at another to the piston (or, also, to the cornet and the trumpet). The instrument is particularly adapted for being used in concerts, inasmuch as by the different sonorous colours more, "light and shade," consequently more variation, is imparted to the execution, and, therefore, no band of musicians should be without it. In a weak orchestral band, in which both bugle horn and piston (respectively cornet and trumpet) are not always represented, this instrument supplies the place of both. Its pitch is high C with B, and A low, and is so constructed that the smaller bell-mouth can be screwed off, in which case the instrument can be used as a common bugle horn (or cornet).

744. Model of the Action of Grand Pianofortes.

Messrs. Erard.

745. Molineux's Patent Self-acting Escapement and Check Repeater Action for upright Pianofortes. It combines extreme simplicity, a firm and elastic touch, with freedom from friction and great durability. *Thomas Molineux.*

746. The first of the now generally adopted **obliquely strung upright Pianofortes,** patented Robert Wornum, of the firm of Wilkinson & Wornum, in 1811.

Messrs. Wornum & Sons.

The large factory in Oxford Street, in which this instrument was made, is shown by an engraving within the lid. This factory was burnt down in October 1812, and the partnership was then dissolved. In the following year Robert Wornum made the first successful "Cottage" pianoforte, with *vertical* stringing, to which he gave the name of "The Harmonic Pianoforte." He accomplished this by discarding entirely the use of brass wires, and adopting the closely-spun copper-covered strings in their stead.

747. Model of the Elastic Tie Action for the Piccolo Pianoforte, invented and patented by Robert Wornum in 1826.

Messrs. Wornum & Sons.

The principles of this mechanism are very generally adopted in France and Germany, as well as in England.

748. Model of Robert Wornum's method of returning the hammer, in his **down-striking Action** for Horizontal Grand and Square Pianofortes, patented in 1842.

Messrs. Wornum & Sons.

This action greatly economises the cost of manufacture. The usual actions are up-striking.

749. Model of Alfred Nicholson Wornum's new **Patent Action** for Grand Pianofortes (1875), in which the heads of the hammers are reversed, and now face the wrest plank, this being effected by an entirely new method. *Messrs. Wornum & Sons.*

By this invention longer strings may be used, relatively to the external dimensions of the case, than in an instrument of the ordinary construction.

750. Model of the action of **Ancient Great Hydraulic Organ,** from Mr. Chappell's description of the instrument.

Dr. Stone.

750a. Model of a Keyboard for an Organ.

Colin Broun.

751. Marimba or Balafo, from South-eastern Africa. Modern. Given by Captain J. Stuart.

South Kensington Museum.

The instrument has twelve slabs of a sonorous wood, beneath which are fastened, by means of a dark-coloured cement, twelve gourds, to increase the sound. In each gourd are two holes, one of which is at the top, and the other at the side. The latter is covered with a delicate film, to promote the sonorousness. Several African travellers have noticed this curious acoustic contrivance. Du Chaillu says that the film consists of the skin of a spider; Livingstone mentions spiders' web being applied to instruments of this kind used by certain native tribes in Southern Africa. The marimba is a favourite instrument of the negroes as well as of the Kafirs.

752. Glass Harmonica. Modern. Made by E. Pohl, in Bohemia. *South Kensington Museum.*

The glass harmonica consists of a series of glass bells, which are affixed in regular order to an iron spindle lying horizontally in a case, and which by simple machinery are set in motion by the feet. The sound is produced by the performer moistening his fingers and pressing them on the bells while these are rotating.

753. Sol-Fa Harmonicon, invented by Miss Glover. Intended as an assistance in learning singing, and the theory of music. *South Kensington Museum.*

754. Organ Pipes, a selection in illustration of their manufacture, showing the middle C pipe of each stop. *H. Speechly.*

755. Chromatic Harmonium, peculiarly constructed keyboard, "showing the twenty-four progressions. The common method is seen at the back of the instrument in connexion with the keys." *Mrs. Read.*

756. Chromatic Pianoforte, peculiarly constructed keyboard, in which the keys are distinguished by different colours. Intended to facilitate the playing in the different major and minor keys. *Mrs. Read.*

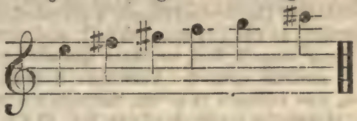
757. Models of several **Ancient Egyptian Pipes,** the originals of which are in the Egyptian Museum at Turin or in the British Museum. Those from Turin are copied in brass, and those from the British Museum in cane.

W. Chappell, F.S.A.

The original pipes were found in Egyptian tombs, some examples being as old as the fourth or fifth dynasty of Egypt. They were played upon by means of a cut, or split, piece of reed, or of straw, inserted in the end, as was usual with ancient shepherds' pipes, and much in the manner of the modern hautboy, or bagpipe, reeds. Parts of the ancient reed or straw remain within one of the pipes in the British Museum, and another at Turin. Usually a fresh long piece of reed or straw was laid in the tomb by the side of the pipe, and it may be assumed that the object was to supply the dead man with a stock of those perishable inciters of tone, in order that he might play continuously upon his pipe when he awoke. Examples of the straws or reeds, so deposited, are included in the Museum at Leyden and in the British Museum.

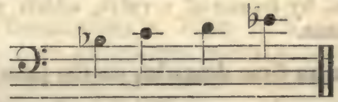
The pipes selected for copying were those which varied in length and in the number of finger holes, so as to obtain varieties of pitch, and varieties of the prehistoric scales. Through the kind assistance of Dr. W. H. Stone, himself an accomplished player upon reed instruments, the following have been ascertained.

1. Pipe from Turin 14$\frac{1}{8}$ inches long, with six finger holes. Scale—



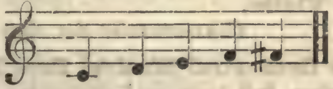
This is the scale of E major, but only extending to six notes. It lacks the addition of D ♯ and E to complete the octave. The fundamental note, or tone of the whole pipe, was not obtained.

2. The longest pipe from Turin, 23$\frac{3}{8}$ inches, but with only three holes. The scale is—

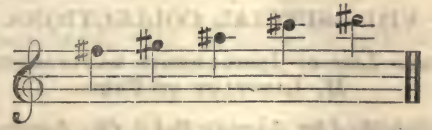


This forms a Diatessarōn, or Fourth, from B-flat to E-flat, therefore one note below our C D E F in pitch. In order to obtain the notes from this pipe, it was found necessary to lower the reed into the pipe, as in the drone of a bagpipe. It extends three inches down the tube.

3. A pipe in the British Museum, copied in cane. It has four holes, and is 8$\frac{3}{4}$ inches in length. The scale is a Diatessarōn, or Fourth, exactly one note above the last, but with an F sharp added to it at the top. Possibly this F sharp may have been intended for a G to make a Fifth; or as F sharp to lead into the key of G upon a treble pipe.



4. Also from the British Museum, copied in cane. It has four finger holes, and the entire length is 10$\frac{1}{8}$ inches. This pipe has a hole bored through it near the mouth end. It would have been absolutely impossible to produce sound from the pipe if this hole had been left open. It may therefore be assumed that it was once covered with thin bladder, such as that of a fish. The intention of placing bladder there would have been to give a tremulousness to the tone of the pipe so as to assimilate it to the human voice. The old English pipe called the Recorder, referred to by Shakespeare in Hamlet, and in A Midsummer Night's Dream was of the same kind, and differed in no other respect from the English flute, both being blown at the end. It is curious to find that such an appreciation of the difference of tone that might be produced has been anticipated by the ancient Egyptians. A film of gutta percha is now tied over the hole. The scale is—



This is a peculiar scale, a pentaphōnic major scale, such as is popularly entitled the Scotch scale. It is suitable for playing tunes upon the black keys of the pianoforte.

It is remarkable that no one of these pipes gives any indication of a minor key, and they seem therefore to be older than the introduction of the minor scale, inherited by us from the Greeks, by the junction of two tetrachords. For this an astronomical or theological reason is assigned, that, as there were but seven planets (according to ancient supposition), and seven days in the week, or quarter of the lunar month, &c., so there should be but seven notes instead of eight in a musical octave. Therefore a scale of two tetrachords, each of four notes, was reduced to seven, through uniting them by one note common to both. Hence the intervals of our B C D E—E F G A.

757a. Indian Vina, with resonating gourds. *W. Chappell, F.S.A.*

757b. Patent Comma Trumpet, producing approximately correct intonation, by means of a valve, which raises the pitch the interval of a comma. *H. Bassett.*

757c. Marimba from **Angola,** on the principle of the musical box. *H. Bassett.*

757d. Wooden Trumpet from **Angola,** made from the root of a tree. *H. Bassett.*

757f. Double Bass, with heavily covered fourth string, going down to C C C. *Dr. Stone.*

758. Series of Acoustic Models. *M. Lancelot, Paris.*

759. Savart Violin. *Conservatoire des Arts et Métiers, Paris.*

759a. A new Orchestral Musical Bass Instrument, with concertina fingering, full tone, and expressive for part and solo performance. *S. F. Pichler.*

759b. Acoustical Instrument, illustrating Harmony and Discord. *S. F. Pichler.*

759c. Violin fitted with Tension Bars. *Dr. Stone.*

759d. Viol d'amore, illustrating the principle of consonating springs. *Dr. Stone.*

759e. Tenor Bassoon, or **Alto Fagotto.** *Dr. Stone.*

VIII.—SPECIAL COLLECTIONS.

Detailed List of Instruments manufactured by M. Lancelot of Paris.

Exhibited by Auguste Bel & Co., London.

760. Eight Pieces of Wood, giving a scale.

761. Mouth of a Flute Pipe, showing the inside of the air-chamber.

762. Wertheim's Apparatus.

763. Pipe with glass side, and membrane.

764. Pipe carrying a slide, enabling holes of different sizes and shapes to be opened in the same situation.

765. Four Pipes, all containing the same mass of air, one cylindrical, one cubical, one tetrahedral, one spherical.

766. Three Pipes containing the same mass of air, one prismatic, one in the shape of a right cone, one in that of an inverted cone.

767. Mons. Bourbouze's Pipe with glass side, bearing three membranes, with mirror, one placed at the node of the first sound, the two others at the two nodes of the second sound.

768. Six Plates, five of different woods, one of brass.

769. Two Flat Rods of brass for transverse vibrations. Support for fixing these.

770. Sonometer on Mons. Barbereau's principle.

771. Circular Membranes, with varied tensions.

772. Two Tuning Forks on resonance box, to give four beats a second.

773. Two Tuning Forks, mounted between the poles of electromagnets, with contact-breaker.

774. Duhamel's Vibroscope.

775. Apparatus for transmission of vibrations through liquids.

776. Instrument for showing the quality of vowel-sounds.

Various Scientific Instruments illustrating the Phenomena of Sound, invented and made by the late John Henry Griesbach.

777. Monochord, with apparatus for printing and registering the vibrations of strings, with a view to ascertaining the number of vibrations per second.

778. Phonometer, by means of which the equally tempered 12 fixed sounds in the octave may be produced.

779. Monochord, giving the positions of the Nodal Points in vibrating strings.

780. Monochord, which affords the means of measuring the 200th part of an inch, with a view to ascertaining the number of vibrations given by that length of string.

781. Apparatus for producing musical sounds, mainly consisting of notched wheels of different diameters, which, being set in motion at a given speed, and duly prepared pieces of cardboard brought in contact with their teeth, produce the notes of the common chord; the number of notches in the wheels corresponding with that of the vibrations required to produce those notes.

782. Apparatus for showing the relative positions of the vibrations of two strings or tubes under the operation of altering the ratios; the strings first tuned to coincidence as unisons, the ratios then altered by lowering the pitch of one of the strings, as from 81 to 80, 82 to 80, or any other numbers within the scale of the apparatus.

783. Set of Flute Pipes, with bellows attached, some of which have too high sounds to be heard singly, but which together give the resultant tone.

784. Large Set of Coloured Diagrams for illustrating lectures on sound.

784a. Collection of Tuning Forks.

One tuned to Handel pitch.
Two in a box.
Two normal diapason.
One tuned to Big Ben.
One C. 528.

784b. Paper printed by J. H. Griesbach to Handel's pitch, and one to the true diapason.

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785. Collection of Acoustic Apparatus.

George Appunn and Sons, Hanau.

785a. Three Acoustic Wind-Chest Tables. These three tables are required for placing all the following apparatus:—

George Appunn and Sons.

1 *Overtone Apparatus,* consisting of 64 lingual tones, the first 64 part tones of the fundamental or key tone (primary sound) $C^{-2} = 32$ vibrations in a second with reed pipes.

2. *The same Apparatus*, consisting of 32 lingual tones, the 32 part tones of the fundamental tone $C^{-2} = 32$ vibrations.

On the overtone apparatus there result quite plainly the corresponding difference-tones of all phases that may be chosen at pleasure; also, up to a certain point, the corresponding resultant tones. By means of this overtone apparatus not only the waves and the quality of the sound can be demonstrated, but likewise the different degrees of harmony of the various musical proportions (rhythm), and of poly-accords in different keys and transpositions. The latter, in particular, in combination with the *tone limit apparatus* for low tones, mentioned hereafter.

3. *Tonometer*, consisting of 65 lingual tones; every subsequent tone higher by 4 vibrations (waves) than the previous one, from $\tilde{c} = 256$ to $\overset{=}{c} = 512$ vibrations in a second; with reed pipes.

4. *Tonometer*, consisting of 33 tones; each succeeding tone being 4 vibrations higher than the preceding one, from $c = 128$ to $\bar{c} = 256$ vibrations in the second.

(*Note.* By the number of vibrations given, double vibrations (waves) are always to be understood.)

5. *Tone-limit Apparatus*, for low (pitch) tones; consisting of 57 lingual tones, with reed pipes, from $c = 128$ vibrations downwards to 8 vibrations in a second, namely, from $c^{0} = 128$ to $C^{-1} = 64$, every subsequent tone in the descending scale lower by 4 vibrations than the next preceding tones from $C^{-1} = 64$ to $C^{-2} = 32$, each two vibrations lower, and, lastly, from $C^{-2} = 32$ vibrations downwards, each one vibration lower as far as 8 vibrations.

6. *Tone-limit Apparatus*, for high (pitch) tones; consisting of 31 small tuning-forks, the diatonic Durton scale c; d; e; f; g; a; h; c;
24 : 27 : 30 : 32 : 36 : 40 : 45 : 48.
through $4\frac{1}{4}$ octaves, namely, from $c^{iv} = 2048$ vibrations (double) to $e^{viii} = 40{,}960$ double vibrations, with two bows.

In order to be able to observe, and to perceive better and more distinctly with the tone-limit apparatus for high tones (tuning-fork apparatus of 31 tuning forks), the ascending scale up to the highest pitch, it will be advisable to intonate with two bows the scales in octaves, one after the other, and thus to sound every tone with its octave simultaneously or one directly after the other.

7. *Two large Gedact Pipes* (stopped mouth pipes), whose pitch can be lowered an octave, with small wind chest and wind trunk, for illustrating the interference, waves, resultant tones, &c.

a. *Two smaller Gedact Pipes*, with small wind chest and wind trunk, for the same purpose.

b. Very powerful-sounding *Lingual* (*reed*) *Pipe*, accompanied by a large number of overtones, with bell-mouth: $C^{-2} = 32$ vibrations in a second.

c. *Twenty-nine Resonators* to the same, from the 4th to the 32nd overtone. (The resonators are conical, and made of zinc.)

d. *Reed pipe*, with bell-mouth, $C^{-1} = 64$ vibrations.

e. Four open and four stopped *Labral Pipes*, with small wind chest and valves, producing the C major accord : $\bar{c} : \bar{e} : \bar{g} : \bar{\bar{c}}$.
8:10:12:16

f. *Accord Reed Pipe*, producing the C major accord $c : e : g : \bar{c} : \bar{e} : \bar{g} : \bar{\bar{c}}$
(The two apparatus *e* and *f* are for demonstrating the quality of sound.)

786. Stand of Apparatus illustrating the progress of Œolian Principles. *J. Baillie Hamilton.*

1. Primitive Æolian types.
   The rod.
   The bow.
   The harp.

2. Modern Æolian harp.

3. Wind concentrated upon a string, and applied to its entire length. By Professor Robinson.

4. Wind applied to a portion of the string, as by Wheatstone, Green, Isoard, &c.

5. Further modifications of the same.

6. Use of a free-reed. By Pape. The connexion with the string being effected by a silk thread.

7. Julian's mode. A metal string flattened into a tongue at the part where the wind impinges.

8. Farmer's mode. A reed-tongue substituted for the flattened portion.

9. Farmer and Hamilton's mode. A rigid connexion between reed-tongue and string allows the reed to be used as in reed-organs.

SUBSEQUENT INVESTIGATIONS BY HAMILTON IN CONJUNCTION WITH HERMANN SMITH.

10. Improved string-organ note, in which a sympathetic resistance is offered to the string, the vibration transmitted to the soundboard, and constancy of pitch preserved by a spring-bow. The reed tone is modified by a tube, and the connexion effected through the tube by a "purse," the latter suggested by Hermann Smith.

11. Further modification by Hamilton. The necessity for the "purse" abolished by setting both reed and string inside the register. The economy of space effected by Hamilton's spiral spring, and the use of a short metal spring-bow.

12. Application of these improvements for use in a wind-viol. Also a conical string, invented by Hamilton, for obviating the following difficulties peculiar to reeds and strings in combination.
   a. The difficulty caused by the string breaking into segments, owing to the constraint on the reed, and the scarcity of notes obtainable.
   b. By the irregularity of intervals which, in a cylindrical string, are crowded together near the reed, and are far apart when remote from it.
   c. By the irregularity of tone in different portions of the string's length. When an ordinary string is used in short lengths the reed's motion is confined, and the tone is consequently

pure; as the string lengthens, the tone becomes loose and coarse.

d. By the reducing of the string's bulk by stretching when tuned, as the reed remains constant the intervals would be changed when the string is thus attenuated.

The conical string meets these difficulties thus,—

a. The bulk of the string lies in the part used for playing upon, and thus no intervals are wasted.

b. The bulk is increased where the intervals would otherwise be wider.

c. The increasing bulk controls the reed equally at all points.

d. If tuned from the smaller end the string does not become attenuated, as more bulk is brought over the other bridge.

13. Apparatus for studying the relative amount of tone contributed through the string.

a. By the action of a soundboard and bridge.

b. By the reciprocal action of a spring-bow.

The spring-bow can also be rendered rigid, and the tone is then due merely to the constraining effect of the string on the reed's motion.

14. Æolian effects produced by percussion. For investigating the causes of the Æolian tone.

15. Apparatus investigating the most effective modes of—

a. Constraint upon a reed.

b. Transmission to a soundboard.

An intermediate mass is here used for transmission.

16. Apparatus showing how far quality of tone can be now affected by reaction from the soundboard. By placing a weight on different parts of the soundboard any quality of tone can be produced.

17. Further modifications for reducing these principles to practical use by altering the relation of levers and spring resistance, and substituting for the intermediate mass the structure of the register, which, as in No. 18, is itself the conductor to the soundboard.

18. Register embodying the foregoing improvements into a form for practical use, and illustrating the different forms of constraint applicable to reeds.

19. A new form of vibrator applicable to all solid bodies as well as to columns of air. Invented by James Baillie Hamilton, April 1876.

20, 21, 22. Apparatus for studying the laws of strings combined with reeds.

IX.—EDUCATIONAL.

787. Apparatus for illustrating lectures. *Auguste Bel & Co.*

788. Graphical Representations of Musical Scales, on paste-board. *Gustav Schubring, Erfurt.*

The logarithms of the numbers of vibrations and their differences where first recognised by *Euler* (Leonhard Euler, tentamen novae theoriae musicae, 1739). These logarithms were at a later period used by *Opelt* ("Natur der "Musik," 1834, "Theorie der Musik") for the graphical representation of musical scales. *Herbart,* likewise, has employed them in his psychological speculations, and, lastly, *Prof. Drobisch* (Leipsic) has extensively applied them in his calculations of the musical intervals (Abhandlungen der fürstlich Jablonowskischen Gesellschaft, 1846).

The exhibited plates are especially intended to illustrate the musical scale calculations of Prof. Helmholtz; they agree in their annotations with those employed in the older edition of the "Lehre von der Tonempfindungen" (Part III., sections 15 and 16). A reconstruction of these plates, according to the annotations used in the new edition, is in course of execution.

789. Model for the Higher Tones.
Gustav Schubring, Erfurt.

Prof. Mach (Prague) has made use of the high-tone scales, drawn according to logarithmic scales, in order to produce a model for the high-scale tones. By means of the same not only can the higher tones of any sound be ascertained directly, but the higher tones of several sounds can also be compared with one another, and the theory of the musical consonance and dissonance advanced by Prof. Helmholtz can be demonstrated in the most excellent manner.

Prof. Mach's model had a length of three octaves, and contained the high tones according to the tempered free-balancing scale.

The model exhibited is more than four octaves long, and contains the high tones in the pure (natural) key.

789a. Model, similar to the two preceding, but not on paste-board. *Gustav Schubring, Erfurt.*

790. Sir Charles Wheatstone's Mechanical Illustration of the Vibration of Strings or Rods.
The Council of King's College, London.

SECTION 7.—LIGHT.

WEST GALLERY, UPPER FLOOR, ROOM Ⓠ.

DETERMINATION—VELOCITY.

791. Original Apparatus, by M. Fizeau, for measuring the velocity of light. *Polytechnic School, Paris.*

792. Apparatus, by M. Foucault, for measuring the velocity of light. *Polytechnic School, Paris.*

I.—DISTRIBUTORS.

a. LENSES.

794. Burning Glass (German), made probably by Count von Tschirnhausen in the 18th century. The property of Prince Pless Furstenstein. *The Breslau Committee.*

798. Early Stereoscope, made by the late Sir David Brewster, the inventor of this instrument. *John Maclauchlan.*

798a. Early Stereoscopic Pictures, prior to the application of photography. From the collection of the late Sir C. Wheatstone. *Robert Sabine.*

798b. Early Stereoscopic Pictures. Daguerreotypes of 1, Biot; 2, Bequerel; 3, Foucault, from the collection of the late Sir C. Wheatstone. *Robert Sabine.*

798c. Seven Earliest designs for the Stereoscope printed in black and white. From the collection of the late Sir C. Wheatstone. *Robert Sabine.*

798d. Early Stereoscopic Pictures. Two Daguerreotypes of Faraday, from the collection of the late Sir C. Wheatstone. *Robert Sabine.*

799. Double Opera Glass. An early example, probably made in Holland about 1700. *South Kensington Museum.*

801. Binocular Field Glasses, Nos. 17, 29, 37.
Voigtländer and Son (Chevalier von Voigtländer), Brunswick.

804. Telescope, No. 14.

Voigtländer and Son (Chevalier von Voigtländer), Brunswick.

807. Iceland Spar Ball, for showing double axis.

A. Hilger.

810. Series of Metrical Glasses. The dioptric unit is a lens of one metre focus; the lens 0·50 to two metres focus is a semi-dioptric value of the unit; the lens 2 to 0·50 focus is a dioptric value of double the unit. The same rule applies to all the other lenses in the collection. *M. Crétès, Paris.*

810a. Globe made of Spar. *M. Lutz, Paris.*

811. Early form of Stereoscope.

The Council of King's College, London.

812. Early form of Stereoscope.

The Council of King's College, London.

812a. Polistereoscope.—Apparatus which serves as telestereoscope, pseudoscope, iconoscope, &c., &c.

Augustus Righi, Professor of Natural Philosophy, Royal Technical Institute, Bologna (Italy).

This apparatus consists of two plane mirrors, one of which (on the left in the figures) can turn about an horizontal and a vertical axis; the other mirror, besides these movements, can be fixed at different distances from the former. The eyes must be applied at two cylindrical tubes fixed to a diaphragm, which can take different positions. One of the eyes sees directly the objects, while the other sees the same object but apparently in a different position. This virtual position can be determined by forming the image of the eye, given by the left mirror, and afterwards the image of the point so determined in relation to the other mirror. If objects not too near are observed the illusion succeeds equally, though the image in the eye which sees by reflection is smaller than the other. According to the inclination which is given to the mirrors, it is possible to make any determinate point of the observed objects appear in the true position.

Fig. 1.—If the apparatus be placed as in Figure 1, it produces the effect of the telestereoscope.

Fig. 2.—Placed as in Figure 2, it acts as a pseudoscope. According to the distance between the mirror, diminution or augmentation of relief can be obtained, together with the inversion of relief. Some curious effects (which cannot be obtained with a Wheatstone's pseudoscope) are observed by looking at rotating geometrical solids, constructed with metallic wire, or by looking at these solids while the observer moves round them.

Fig. 3.—With the apparatus placed as in Figure 3, the effects of an iconoscope are obtained. A very narrow mirror is substituted for the large mirror.

Fig. 4.—In Fig. 4 the apparatus is placed so that the eyes see the objects as if they were in a same plane perpendicular to the right line which joins the eyes; the relief in objects made with vertical wires then disappears. If the diaphragm which bears the two tubes is kept fixed, and the instrument turned slowly round the left tube, very curious apparent motions occur in the objects under observation.

For the mathematical theory of this apparatus, *see* the "Nuovo Cimento," 2^{d} ser. t. xiv.

813. Jewel Lens (Ruby) of $\frac{1}{60}$ inch focus. Made by Andrew Pritchard, at the suggestion of Sir David Brewster. (*See* Brewster's "Optics," 1831, p. 337.) *John Spiller, F.C.S.*

813a. Vertical Apparatus for Projections. *M. J. Duboscq, Paris.*

813b. Projecting Apparatus, for all phenomena of double refraction and polarization. *M. J. Duboscq, Paris.*

813c. Support, with Reflector, by Fresnel. *M. J. Duboscq, Paris.*

b. LANTERNS, CAMERAS, &C.

814. Oxy-hydrogen Lantern, of new form, suitable for lecturers. *C. J. Woodward.*

The lantern is mounted on a "Willis's stool," so that supports of various kinds may readily be attached. The body of the lantern is swung between two uprights, and can be clamped so as to send a beam of light at any angle; this, combined with a rotatory motion in a horizontal plane, enables the lecturer to direct a beam in any required direction. A rod carries lenses and a mirror when it is required to throw the light vertically upwards on an object, as, *e.g.*, for cohesion figures.

816. Camera Obscura. An early example, said to have belonged to Sir Joshua Reynolds. *South Kensington Museum.*

This camera when closed has the form of a large folio leather-bound book. It is recorded to have been given by Sir Joshua Reynolds to Lady Yates, by whose great grand-daughter, Mrs. J. R. Harrison, it was, in May 1875, presented to the Museum.

816a. Camera, by Colonel Laussedat. *M. Lutz, Paris.*

816d. Camera Lucida, invented and used by Dr. W. H. Wollaston. *G. H. Wollaston.*

816g. Camera Lucida, with slight magnifying power. *A. Nachet, Paris.*

816h. Camera for Landscapes, by M. Govi. *A. Nachet, Paris.*

816i. Camera Lucida, invented and used by Dr. W. H. Wollaston. *G. H. Wollaston.*

816j. Wollaston's original periscopic Camera Lucida. *See* Tilloch, xxvii. (1807), p. 343; Phil. Trans., 1812, p. 370. *Wollaston Collection, Cavendish Laboratory, Cambridge.*

816k. Wollaston's Camera Lucida adapted to Telescope. *Wollaston Collection, Cavendish Laboratory, Cambridge.*

817. Improved Electric Lamp and Lantern for Lecturer's use. *John Browning.*

The lamp is automatic, the carbon poles being drawn asunder in proportion to the strength of the battery power used; this is effected by drawing iron rods into a hollow coil of insulated copper wire. The lantern has two nozzles, one intended for exhibiting screen experiments in spectrum analysis, polarisation, refraction, reflection, diffraction, &c., the other for exhibiting diagrams on the same screen, without altering the arrangement of the apparatus for physical experiments.

818. Lithographs for the Stereoscope, from drawings by J. Müller, Hessemer, Oppel, Nell.
J. Wilhelm Albert, Frankfort-on-Maine.

The coloured drawing marked with A (upon grey cardboard) is the original made by the late Prof. *Müller.* Images 2, 3, and 4 serve for a stereoscope without glass. The other images refer to stereometrical, astronomical, and optical subjects (colour combinations). Some images appear, by a slight change of position, in low or high relief.

819. Edelmann's Spectral Lamp, for the projection of spectra, with printed description. *M. Ph. Edelmann, Munich.*

821. Duboscq's Lantern. To be used in connexion with the following apparatus:—

1. Top with illuminating lens; is to be employed with spectral slit and polariscope.

2. Spectral slit; can be regulated by means of a fine screw.

3. Stand with convex lens; serves for the projection of the rays in spectrum experiments.

4. Two hollow prisms.

5. Prism plate for two prisms, arranged for being turned and put higher or lower.

6. Stand with holder for a prism; can be regulated.

7. Polariscope.

8. Lens system, with four-inch illuminating lenses and achromatic objective; serves for the projection of photographic and other images of about 3 inches in diameter.

9. Microscope. This can be screwed to the end of the preceding system of lenses, after the objective has been removed.

10. Regulator for producing electric light.

11. Hydro-oxygen gas lamp.

A. Krüss, Hamburg.

Apparatus for the use of Lecturers, to show sketches, drawings of instruments, anatomical preparations, &c., by means of hydro-oxygen illumination, arranged for the projection of opaque objects. *A. Krüss, Hamburg.*

821a. Photogenic Lantern. *M. J. Duboscq, Paris.*

822. Double demonstrating Oxy-hydrogen Lantern, with triple condensers, consisting of two 10-inch plano-convex lenses, and a 7-inch meniscus, next to the source of light. The last lens is made to slide backward and forward between guides, so as to increase or diminish the cone of rays, and enable large or small diagrams or pictures to be exhibited without material distortion. *Dr. Stone.*

823. Magnesium Lamp, provided with brass cylinders and reflector. *A. Herbst, Berlin.*

824. Brewster's Patent Kaleidoscope (with case). The original form of the instrument made by Bate, of London, in the year 1815. (Position of the reflectors capable of adjustment, non-central eye piece, and rotating terminal disc, or box containing the coloured glass.) *John Spiller, F.C.S.*

II.—SELECTORS.

a. SPECTROSCOPES, PRISMS, &c.

825. Photographic and **Spectro-photographic Specimens** and **Apparatus** of Sir John Herschel and Sir William Herschel. *Prof. A. S. Herschel.*

1. Original fragments and complete photographs on glass with chloride of silver of the forty foot telescope at Slough. Produced in 1839 by Sir John Herschel, as a new modification of the process of Daguerre. Paper wrapper of the specimens inscribed in autograph by Sir John Herschel with the above description of the plates.

2. Prismatic apparatus designed and used in researches on the photographic action of the different rays of the spectrum, by Sir John Herschel, Slough, 1839. Original description, and notes of experiments with the instrument extracted from MS. journal. Specimens of photographed spectra obtained with the instrument by Sir John Herschel, at Collingwood, in 1859.

3. Heliostatic mirror (used by fixing outside to aperture in a window shutter, and turning screws by hand inside to direct the sun's rays horizontally or in a required direction). Glass prism to receive and bend downwards the reflected ray to a table on which thermometers were exposed to action of the different rays of its spectrum. Constructed and used (with other apparatus not preserved) by Sir William Herschel, in experiments on thermal radiation in the solar spectrum, described in the Philosophical Transactions, 1800–1801.

A plate of light blue cobalt glass, mounted on cardboard diaphragm pierced with an eye-hole; used with the prismatic photographing apparatus to examine test papers submitted to the solar spectrum (before sensitizing), and to mark with pencil on the test paper the exact position of a certain yellow colour of the spectrum. When the paper had been thus fixed and marked, the sensitive solution to be tested, if not already present in the paper, was applied to its exposed surface with a brush, and the time of exposure and intensity of the direct sunlight was at the same time recorded. Two small card-leaves have, for the purpose of examination, been attached to the cardboard diaphragm, by closing which upon the glass, the "fiducial" yellow ray transmitted by blue cobalt glass will be observed with the accompanying eyepiece of a small pocket spectroscope placed with the plate. Through the narrow slit left between them the selective absorption of the glass can easily be distinguished if white light is examined through it, and spectroscopically analysed by means of the dispersion of the prisms.

825a. Fluorescent Eyepiece, by M. Soret, for adaptation to the **Spectroscope.**

Geneva Association for the Construction of Scientific Instruments.

It consists of a plate made of a fluorescent and transparent substance (uranium glass or different liquids contained between two glass plates), which is placed in the focus of the objective of the spectroscope. The ultra-purple spectrum projected upon this plate becomes visible, and is observed through an eyepiece which is movable upon the axis of the observing telescope. A very intense light is necessary. (For description of this apparatus, *see* Poggendorff's Annalen, 1274. Jubelband, p. 407; Archives des Sciences physiques et naturelles, 1874, vol. 41, p. 338; and 1875, vol. 54, p. 255.)

825a. Combination of Three Prisms of different dispersive power, giving by one combination deviation without dispersion, and by another dispersion without deviation. Formerly the property of Dr. Priestley. *Mrs. Parkes.*

825b. Apparatus used by **Sir C. Wheatstone** in his early researches in **Spectrum Analysis.** *Robert Sabine.*

825c. Arrangement of Apparatus for Experiments on the Assay of Gold Alloys, by means of the Spectroscope, in the manner suggested by Mr. Lockyer.

W. Chandler Roberts, F.R.S.

The apparatus consists of:—

(1.) An induction coil, capable of giving a 10-inch spark in air, which is provided with a Foucault contact breaker in order that the spark may be perfectly continuous.

(2.) A frame on which the portions of metal under examination can be so arranged as to be easily brought in succession under a fixed pole of aluminium. Accompanying this frame is a fixed microscope provided with cross wires in the eyepiece, and the table bearing the assay pieces can be adjusted by a micrometer screw, so that the image of the apex of each assay piece can be brought to coincide with the cross wires, thus ensuring that the striking distance remains constant.

(3.) A lens to throw an image of the spark on the slit of—

(4.) A large spectroscope in which the spectra of the alloys are examined. It is provided with a micrometer, the wire of which is horizontal and moves in a vertical plane.

When a spark from the induction coil (the two terminals of which are also connected with the coatings of a Leyden jar) passes between the aluminium pole and one of the alloys, an atmosphere of the vapours of gold and copper is formed round the lower pole which does not extend to the upper pole, and therefore in the spectrum observed the lines due to these metals will not cross the field of view. Mr. Lockyer observed, that, when all other conditions remain the same, if the composition of the alloy be slightly altered, the relative heights and intensities of the lines of the two metals vary. For these comparisons the gold line having a wave length of 5,230 tenth-metres, and the copper line 5,217, are the most convenient. If a series of known alloys varying slightly in composition is examined, a curve may be constructed, the ordinates of which represent the ordinary assays, and the abscissæ the micrometer readings for the points at which the above two lines are equally bright, and then, theoretically, if an unknown alloy of about the same composition be examined, this curve enables us to determine its exact composition when the micrometer reading is known.

In practice, however, it is found necessary to vary the striking distance with the composition, and the amount of this variation is still under investigation.

826. Spectroscope for determining the smallest displacement of spectral lines, and for measuring the velocity of motion of the object. *Professor Carl Wenzel Zenger, Prague.*

This new instrument gives double images, two spectra produced by an additional prism of quartz or calcspar, giving two dark lines in parallel directions, *e.g.*, the D. line, and of constant distance, if there be no motion towards or from the luminous body. The motion of heavenly bodies producing, therefore, the displacement of both D lines, and an accurate micrometer measuring it, gives the amount of velocity.

827. Hermann's Haematoscope, for examination and demonstration of absorption bands in fluids by the spectroscope. *Professor Dr. L. Hermann, Zürich.*

The fluid is poured into the little chamber, and the thickness of the layer is regulated by sliding the inner tube until the bands appear.

828. The Collection of Prisms of crown and flint glass used in the construction of refractors and spectroscopes by Steinheil and Merz at Munich, and by Hofmann at Paris, whose refractive indices for 50 lines in the solar spectrum were determined by Prof. Van der Willigen. *Teyler Foundation, Haarlem.*

Steinheil No. I. flint, No. II. flint, No. III. crown glass.

Merz No. I. and No. II. both of the same heaviest flint, No. III. crown, No. IV. crown, No. V. and No. V*a*. both of the same ordinary flint glass.

Hofmann No. I. heavy flint glass.

See "Archives du Musée Teyler," Vol. I. p. 31, 64 and 205, and Vol. II. p. 183.

See the chemical composition of crown Steinheil No. III., and Merz No. IV., and of flint: Steinheil No. II., Merz No. I. and No. II., and No. V. and No. V*a*., and Hofmann No. I., given by the late Prof. P. J. van Kerckhoff, "Archives du Musée Teyler," Vol. III. p. 117.

Steinheil No. II. and No. III., Merz No. I. and No. II., No. IV. and No. V. and No. V*a*., and Hofmann No. I. are accompanied by parallelopipeds and plates of the same glass and by pieces or powder for chemical analysis.

829. Powerful Spectroscope, with Browning's automatic action, for adjusting the prisms to the minimum angle of deviation of the ray under examination. *John Browning.*

In this instrument the ray can be made to pass four times through the six prisms, and a dispersive power of 24 prisms thus obtained can be used, or that of any lesser number of prisms at pleasure. The instrument is fitted with a new reflecting bright line micrometer; when measuring with this contrivance no light is visible in the field of view, but the wires of the micrometer are seen faintly illuminated.

830. Universal Spectroscope, with Browning's automatic action, giving a dispersive power of from 2 to 12 prisms.

John Browning.

•**791. Rotating Tube Holder,** a contrivance for containing a number of Plücker's tubes, and obtaining their spectra successively without loss of time. *John Browning.*

792. Rotating Metal Holder, suggested by Mr. Lockyer, for holding specimens of all the principal metals, and obtaining their spectra successively, or for the purposes of comparison.

John Browning.

831. Direct-vision Spectroscope, with apparatus for registering observations.

Geneva Association for the Construction of Scientific Instruments.

This direct-vision spectroscope is distinguished from others of the same description, in that the distance of the lines of the spectrum is measured, not by the superposition of the spectrum upon an illuminated micrometric scale, but by measuring the angle formed by the eyepiece in moving the cross wires of the telescope from one line to the other, and then comparing it with that formed by the telescope when directed successively to two lines of known distance. A tangent screw effects the angular displacement of the telescope; this screw is graduated on the head to read angular displacements of less than 20 seconds. A recorder, formed of a movable pencil which acts upon a counter, serves to make series of observations in the dark. The collimator telescope possesses also an angular motion, which serves to bring any portion whatever of the spectrum to the centre of the field of view.

832. General Apparatus for Spectroscopy, Polarisation, Reflexion, Refraction, and for various experiments in **Fluorescence.**

Geneva Association for the Construction of Scientific Instruments.

This apparatus has been constructed with the object of carrying out, with one and the same instrument, all, or nearly all, experiments in spectroscopy, rotatory polarisation, reflection, and refraction. The divided circle is movable around an axis, and serves to bring the rays of light at any angle upon the eyepiece of the line of collimation. For experiments in spectroscopy, a table of one, three, or six prisms may be set up. The prisms are raised above the divided circle sufficiently to allow of their being heated from below if required. For determination of the line of collimation suitable arrangements have been provided, and for experiments in polarisation, eyepieces fitted with divided circles and nicols; a Babinet compensator may also be adapted to them.

The first apparatus of this kind was constructed for the use of Professor Wiedemann, of the University of Leipzig.

833. Large Spectroscope, according to Meyerstein's system, for determining the relations of refraction and dispersion of different media, with contrivance for polarisation.
Schmidt and Haensch, Berlin.

834. Smaller Spectroscope, of the exhibitors' own construction. *Schmidt and Haensch, Berlin.*

835. Spectroscope, according to Abbe's system, with divided circle of 20 cm. diameter, repeating circle, and micrometer apparatus for determining the dispersion. Also a hollow prism with metal body. *Carl Zeiss, Jena.*

The spectroscope has only *one* telescope, which serves at the same time for collimation and observation. The adjustment brings about automatically the minimum deviation for every ray. The measurement of the refracting angle and that of the deviation takes place without change in the instrument. The determination of the dispersion is effected, independently of ascertaining the absolute refractive index of *one* colour, by micrometric measurement.

836. Two Prisms of Glass, for observing the **dispersion** of coloured liquids; constructed by Steinheil, of Munich.
Prof. Kundt, Strassburg.

The refracting edge of the hollow prisms is so sharp that they show the dispersion of even highly coloured liquids.

837. Spectroscope, with five-inch circle, according to Dr. Meyerstein's system, for measuring the refraction and dispersion of different media, for chemical and optical analysis, as well as for all kinds of goniometrical measurements.

There are belonging to this :—
a. Small circle with pivot and plate.
b. Telescope with stand.
c. Slit tube (Spaltrohre).
d. Scale tube.
e. Crystal stand.
f. Prism.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

The telescopes, when required, are screwed on to the places marked "Fernrohre," "Spaltrohre," &c. The small circle is put into the middle of the larger one. To determine the refracting angle of a prism, the telescope is attached to that part of the instrument which is marked "Zur Bestinmung, &c.," it is left here for all goniometric measurements, but the smaller circle is removed and the crystal-holder put into its place.

838. Spectroscope, of the latest construction, according to Dr. Meyerstein's system, arranged for the relations of refraction and dispersion of different media, for the reflection of polarised light at the free surface of liquids, as well as for the reflection of solid bodies, for all kinds of goniometrical measurements, and for chemical and optical analysis.

There are belonging to this :—

- *a.* Small circle with plate.
- *b.* Two telescopes.
- *c.* Two slit-tubes (Spaltrohre).
- *d.* Scale-tube.
- *e.* Babinet's compensator.
- *f.* Two weights for balancing telescope and slit in a vertical position.
- *g.* Crystal stand.
- *h.* Flint-glass prism.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

For attaching the telescopes, collimators, &c., the same rules apply as in the previous case. The larger telescope and collimator serve for determining the refraction and the refracting angle; the small tubes are for the polarisation. Determination of refraction and of refracting angles are effected as with the larger instrument, except that the telescope is put into the place of the micrometric tube. Solid bodies, when submitted to polarisation, are fixed with some wax against the plate which is put up in the black dish. When liquids are to be investigated, the small circle with its clamps is entirely removed, the screw, which maintains the principal circle in horizontal position, taken out, and the instrument turned down until the main circle stands vertically, when it is fixed again by the screw. For all polarisation experiments a *Babinet* compensator is fixed by means of the two screws upon the bearer of the telescope.

839. Hollow Prism, according to Dr. Meyerstein, which is used for optical analysis with the spectroscope.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

840. Rigid Spectroscope by Browning, constructed for Mr. Gassiot on the design of Dr. Balfour Stewart, with the view of determining whether the position of the D lines of the spectrum is constant, whilst the co-efficient of terrestrial gravity is made to vary. *Kew Committee of the Royal Society.*

It is described in the Proceedings of the Royal Society, Vol. XIV., p. 320.

Observations were made by it from 1866–1869, on board H.M.S. "Nassau," during a voyage to and from the South Pacific, and subsequently at the Kew Observatory until 1872, the results of which are not yet published.

It consists of a train of three prisms, the last of which is silvered on one side, so as to return the light which falls upon it. Close to the slit another prism is placed, which reflects the rays on their way back into a micrometer, by which the position of the D lines is measured."

841. Vierordt Spectroscope, adapted for the measurement of absorption spectra and for quantitative chemical analysis.

Schmidt and Haensch, Berlin.

This apparatus is described in Vierordt's work on the "Application of the Spectroscope to the Photometry of Absorption Spectra, and in Quantitative " Chemical Analysis." Tübingen, 1873.

843. Mitscherlich's Stand for use in the spectroscopic examination of coloured flames.
Prof. A. Mitscherlich, Münden.

843a. Direct-vision Spectroscope of great dispersive power, provided with a specially constructed micrometer for measuring intervals between lines to ·0001 in. *A. Hilger.*

843b. Two powerful Direct-vision Spectroscopes, 7 in. in length. *A. Hilger.*

844. Pocket Spectroscope, showing sodium line in a simple burning candle, of great use in chemical and meteorological observations. *A. Hilger.*

845. Hilger's Pocket Spectroscope, showing all the principal Fraunhofer lines, dividing D easily with nickel line between; when on sun, a sliding slit with division adjustable to position. besides a limb in front of eyepiece. *A. Hilger.*

846. Pocket Spectroscope of the simplest and cheapest kind. *A. Hilger.*

847. Rhomboid of Iceland Spar. *A. Hilger.*

Iceland Spar Prism of 60°, 1½ in. surfaces, single refracting. *A. Hilger.*

Spar Prism, 1⅝ in. surfaces. *A. Hilger.*

Flint Prism, 1⅛ in. surfaces. *A. Hilger.*

Flint Prism, 1 in. surface. *A. Hilger.*

Two Half Prisms, 1 in. surface. *A. Hilger.*

Lateral Flint Prism, 1⅜ in × 3 in. *A. Hilger.*

Three compound Direct-vision Prisms, one of a new form receiving light at right angles. *A. Hilger.*

Four compound Prisms without colour. *A. Hilger.*

Two dull Glass Prisms for photometric use. *A. Hilger.*

Nicol Prisms for polarisation. *A. Hilger.*

Double Image Prism. *A. Hilger.*

Parallel Plane Glass Plate, surface 3 in. × 2½ in.
A. Hilger.

848. Nicol and a Double Image Prism. *A. Hilger.*

848a. Large Prism of 60°, with perfectly worked surfaces 3 in. by 3⅝ in. of the finest Thalium glass, on brass stand.
A. Hilger.

848b. Two Nicol Prisms mounted for polarisation.
A. Hilger.

849. Spectroscope made by Yeates, of Dublin, fitted with a diaphragm instead of cross threads for measurement of position of lines. *Prof. Jos. P. O'Reilly.*

The diaphragm, above, being perfectly opaque, is always visible against even the faintest lines; moreover, it dispenses with the introduction of an extraneous light which may by its brilliancy interfere with that of faint lines. This spectroscope is specially adapted for the examination of fluorescent minerals, the prisms and lenses being of quartz.

850. Spectroscope, with bi-sulphide of carbon prisms and lens, arranged for projection. *Yeates & Sons.*

The prisms and collimating lens are so proportioned that no light is lost by passing outside the prisms or otherwise.

851. Spectroscope, with compound prism and angular scale. *Yeates & Sons.*

852. Spectroscope, with two prisms. *James How & Co.*

853. Three Foucault's Prisms.
Iceland-spar, cut in three directions.
Small rhombohedron of Iceland spar.
Cone and pyramid (black) for Guérard's apparatus.
Cone for the projection of annular spectrum.
Pyramid for the projection of four spectra.
M. Mascart's prism.
Prism of crown glass.
Two polyprisms (glass).
One polyprism (quartz).
Collection of nine prisms.
Boscowich prisms.
Fresnel's tri-prism.
Fresnel's Parallelopipeds, mounted in brass.
Laurent, Paris.

854. Prisms for direct Vision in 3 pieces.
,, ,, ,, **5** ,,
,, ,, ,, **7** ,,
Rochon prism.
Wollaston prism.
,, ,, (small).
Achromatized Iceland spar prism.
Cube of fluor-spar.
Fluor-spar lens.
Cemented cells for spectroscopic work (9).
Tubes with platinum wire (6).
Collection of quartz and Iceland spar prisms.
Spectroscope with one prism, one and two burners.
Object-glass for projecting ray spectra.
Laurent, Paris.

854a. Collection of Prisms, for optical purposes. *Laurent, Paris.*

854b. Spectroscope. *M. J. Duboscq, Paris.*

854c. Prisms, by Arago. *Paris Observatory.*

854d. Prisms, by Borda. *Paris Observatory.*

854e. Collection of various kinds of **Glass** for optical purposes. *Feil, Paris.*

1. Disc of Crown Glass, 4 inches.
2. Disc of Flint Glass, 4 inches.
3. Plate of Crown Glass (heavy English).
4. Parallelopiped, of ordinary flint glass.
5. Crown Glass Prism.
6. Flint Glass Prism.
7. Flint Glass Prism, (sp. gravity 4·4.)
7a. Prism manufactured by Fraunhaufer Guinand.
8. Flint Glass Prism (very heavy), sp. gr. 4·4.
9. Flint Glass Prism, sp. gravity 4.
10. Flint Glass Prism, sp. gravity 5·2.
11. Flint Glass Prism, sp. gravity 5·5.

Series of Assays of the Metallic Earths.

11a. Silicate of Potassium and Calcium with Titanium.
12. Aluminate of Silicium and Magnesium.
13. Crystallisation of Alumina and Magnesia.
14. Crystallisation of Fluosilicate of Magnesium and Calcium.
15. Alumina and Magnesia Crystallised by Fluosilicate of Potassium.
16. Crystallisation of Fluosilicate of Aluminium.
17. Crystallisation of Barosilicate of Aluminium.
18. Crystallised Aluminate of Magnesium and Silicium.
19. Manufacture of Adamantine Boron.
20. Plate of Crystals of Aluminium.
21. Blue Obsidian.
22. Obsidian coloured by Cobalt.
23. Samples of Crown Glass, extra white.

854f. Objective of Rock Crystal, 10 centimetres in diameter. *M. Lutz, Paris.*

854g. Astronomical Glasses, for cabinets of physics. *M. Lutz, Paris.*

855. Micro-spectroscope, with prism for comparing two spectra, and with Abbe's measuring apparatus for the direct estimation of the wave lengths of dark or bright lines in a spectrum. *C. Zeiss, Jena.*

This spectroscope gives the position of the bright or dark lines by means of a scale on which the spectrum is thrown, and which, by means of its peculiar graduation and numbering, allows the wave length at any place to be read off in micro-millimetres.

856. Apps' Improved Gas and Electrode Holder for Spectrum Analysis. *Alfred Apps.*

857. Improved Automatic Chemical Spectroscope, invented and made by the contributor. The object glasses and prisms by Chas. Owen, Optician, Strand.

Rev. Nicholas Brady.

Prisms with a circular face are cemented to the object glasses of the collimator and telescope, the circular face of the prisms being of the same size as the object glass. The base is rectangular to the surface of the object glass, and the refracting angle about 30°. The beam of light rendered parallel by the collimating lens passes through the first half prism perpendicularly and suffers no refraction, but is refracted on emergence from its exterior face; the refracted and dispersed beam is received on the external face of a second object glass prism, suffers more refraction and dispersion, and, emerging at a perpendicular incidence, is taken up and brought to a focus by the object glass. In all positions the ray under examination passes parallel to the base of the prisms, and therefore at the angle of minimum deviation. The variation of the angle between the two prisms by the motion of the tangent screw of the telescope merely brings one ray after another into the field of view. This automatic arrangement gives a dispersion equal to one dense glass prism of 60°. Should greater dispersion be required a prism of 60° has been arranged in the centre of the instrument, which by a very simple automatic contrivance of one lever and a slot is moved by the arm carrying the telescope, so that any ray is still preserved at the angle of minimum deviation. A further advantage of this new principle is, that with these object glass prisms the field is completely filled with light, which has not usually been the case, unless the prisms are extra large, and therefore expensive; and if a train of prisms be inserted their faces only require to be equal for them still to entirely illumine the field: thus much light is gained. and comparatively little is lost by absorption and reflection, as the surfaces are fewer, so that the violet end of the spectrum is very extensive, and fine lines beautifully defined.

858. Gas Lamp Apparatus for placing before the slit of the spectroscope with Bunsen burners, &c., insuring the proper adjustment of the platinum wires carrying the substance under examination in the flame without displacing the eye from the ocular of the telescope; and also an arrangement for quickly and efficiently exchanging one or both burners for either one or two vacuum tubes. *Rev. Nicholas Brady.*

Two photographs accompany the instrument, showing its use in two different positions.

859. Ordinary Spectroscope, arranged for the exhibition of diffraction phenomena, with apertures and gratings, &c. of various kinds, under common and polarised light, and with the means of observing the spectra of the diffracted beam. Designed and made by exhibitor. *Rev. Nicholas Brady.*

971c. Curve for obtaining **Wave-lengths** of **Spectra;** and **Map** of the absorption spectra of bromine and iodine monochloride.
Professors Roscoe and Thorpe.

857a. Automatic Motion for the Spectroscope.
Walter Baily.

The apparatus consists of an axle and four parallel discs, the outer pair being fixed, and the inner pair rigidly connected together, and capable of turning on the axle. Between the inner discs are four arms, which also turn on the axle.

Taking the centre of the axle as origin, each disc has 4 slits, the equation to their middle lines being $r=\mathrm{F}(\theta)$, $r=\mathrm{F}\left(\frac{\theta}{2}\right)$, $r=\mathrm{F}\left(\frac{\theta}{3}\right)$, $r=\mathrm{F}\left(\frac{\theta}{4}\right)$. The discs in each pair are placed with their slits parallel, but the inner discs are turned over. The arms have straight slits radiating from the axle. A pin is passed through the first slits of the outer discs, the 4th of the inner discs, and the slit in one of the arms. The remaining arms are connected with the discs by three other pins inserted in a similar manner. The first and last prisms are fixed on the initial lines of the outer and inner pair of discs respectively, and the four other prisms are carried by the arms. Motion is given by moving the inner discs. The angles at which the slits cross are constant and differ least from right angles if $\mathrm{F}(\theta)=ae^{-\theta\sqrt{5}}$, which is the form adopted in the model.

859a. Photo-Spectra of Metals and Gases, obtained with a **Browning Direct-vision Spectroscope.**
John Rand Capron.

These spectra were photographed with wet plates by J. R. Capron and G. H. Murray, for use and reference in connection with auroral investigations.

The optical apparatus consisted of a Browning direct-vision prism, with, in the case of metals, a collimating lens of 6-inch focus, and a projecting lens of 9-inch focus. For the gases a similar prism was used, with collimating and projecting lenses, each of 4-inch focus. The photographs are enlarged to twice the originals. The electrical apparatus consisted of a 4½-inch spark Ruhmkorff coil, worked by four half-gallon bichromate cells, a condenser of four glass-coated plates, and spark terminals.

The spark was placed about half an inch from the slit. Mr. Lockyer's plan of interposing a lens was tried in some cases, but given up, as the long and short lines were found to be equally well observed in the spark itself. The gases were mostly in Geissler tubes. It is proposed in further experiments to get rid of the air lines by taking the spark between the metal electrodes in glass bulbs, through which a gas passes.

One of the spectra represents the spark between platinum electrodes taken in a current of coal gas passing through a tube.

The dispersion of the direct-vision prism is as follows:—A = 17·62; B = 23·62; C = 30·42; D = 50; E = 77·35; F = 103·90; G = 159·73. With the instrument as used for the gases, it is found possible to photograph faint spectra satisfactorily.

b. POLARISCOPES, &c.

861. Jellett's Saccharometer, for the measurement of the rotation which certain fluids are capable of producing in the plane of polarisation of the transmitted ray. *Trinity College, Dublin.*

This rotation is measured by the method of compensation, the original position of the plane being restored by transmission through a column of fluid possessing an opposite rotatory power. This fluid is contained in a vessel closed at the bottom with glass, and the length of the column is regulated by means of a tube, also closed with glass, which is capable of moving in the direction of its axis, the amount of this movement being read off on a scale.

A full description of the instrument and of the analysing prism used in its construction is given in the "Transactions of the Royal Irish Academy," Vol. XXV., pp. 373–82.

861a. Laurent Polarimeter and Saccharometer, with two divisions on the plate, with inversion tube and one thermometer. *Laurent, Paris.*

861b. Saccharometer, by Soleil, with penumbra (large model). *M. J. Duboscq, Paris.*

861c. Large Circle, by Messrs. Jamin and Sénarmont. *M. J. Duboscq, Paris.*

861d. Large Circle for measuring the elements of elliptic and rotatory polarisation in solids and liquids, and reproducing all impressions of polarisation and refraction. (This apparatus belongs to the School of Photography.) *M. Lutz, Paris.*

862. Polarising Apparatus, according to Dove's system, complete, with polyoscope and dichroscope. *Schmidt and Haensch, Berlin.*

863. Simple, handy Polarising Apparatus, according to Carl's system. *Schmidt and Haensch, Berlin.*

864. Melde's Models, for illustrating the **colours of thin leaves** in polarised light. *Ferdinand Süss, Marburg.*

865. Melde's Model, for illustrating **circular polarisation** by means of gypsum and scales of mica. *Ferdinand Süss, Marburg.*

866. Paste-board Models, according to J. Müller's system, for illustrating the **colour phenomena** in **polarised light,** and the **uni-axial** and **bi-axial crystals.** *J. Wilhelm Albert, Frankfort-on-Maine.*

Ten models of cardboard, together with a treatise on them. Described in *J. Müller's* "Lehrb. der Phys., 7 Aufl., I. Bd., 3tes. Buch, caps. 9 and 10."

867. Polarising Apparatus, for projection with rotatory analyser, according to E. Mach's system, with quartz plate and $\frac{1}{4}$ undulation plate. (Comp. Poggendorff's Ann., 1875, No. 12.) *J. Wilhelm Albert, Frankfort-on-Maine.*

The ray of sun or electric lamp falls through a Nicol, which is protected with a shade, upon a press, in which the object is fastened by means of spring clamps, and passes thence through a tube which can be rotated with great velocity. This tube is provided at one end with a shade capable of rotating with the tube, and the analysing Nicol over which there is a slit or a square aperture.

At the end of the tube is a deflection prism of crown glass, to which, for some investigations, a direct vision prism is added. The ray, as it issues from the tube, is received by a lens, which throws upon a screen a sharp image of the slit or square aperture. This image moves in a circle as the azimuth changes, and thus shows by quick rotation all the phenomena which, in ordinary polarising instruments, appear successively *side by side.*

868. Twelve Plates with Pictures, of gypsum and mica, for polarised light. *Prof. Karsten, Rostock.*

The form of images has been chosen to represent the different colours of thin plates in polarised light. Any kind of polarising apparatus may be employed for these observations.

869. Nörremberg's Polarising Apparatus, small size. *W. Apel, Göttingen.*

870. Nörremberg's Polarising Apparatus, large size; according to the design of Professor Listing. *W. Apel, Göttingen.*

The apparatus serves not only for purposes of lecture demonstration, but also for accurate measurements. The advantage of the instrument over the ordinary polarising microscopes lies in the circumstance that in the *Nörremberg* apparatus the polarised light passes to and fro through the same crystal plate, when placed on the horizontal mirror. The movable glass plate of the middle table serves for measuring the angle of the optical axes by means of a graduated semicircle.

870a. Large Apparatus by Norremberg, improved by Wheatstone. *M. Lutz, Paris.*

870b. Apparatus used for observing the **Polarisation** of **Light** in **Water.** *J. Louis Soret, Geneva.*

It is formed of a telescope tube closed on the objective side by a glass plate. The eyepiece is formed of a "Nicol" prism.

The observer, placed in a boat, immerses the objective end of the tube and looks through the "Nicol." He then finds the light of blue coloration reflected by the lower strata under the surface of the water, and by turning the Nicol ascertains if it is polarised.

See "Notes sur la Polarisation de la Lumière de l'Eau." Archives des Sciences physiques et naturelles, 1869, Vol. 35, p. 84, and 1870, Vol. 39, p. 352.

871. Apparatus for the Observation and Measurement of the cyclopolar double refraction of Quartz in the direction of the optical axis. Designed by Professor Listing, executed by R. Winkel in Göttingen.

Royal Mathematical and Physical Institute of the University of Göttingen, Prof. Listing.

The telescope can, before being put into the holder of the apparatus, be adjusted for distant objects, or for an object of but 2–3 meters distance from the object glass. The *Fresnel* triple quartz prism is fixed in upright position in the support below the telescope, and protected by a cardboard shade against side lights. By means of the achromatic lens, situated below the prism, a virtual image is produced of an appropriate object (line cut by a diamond upon glass, &c.), placed upon the black table, which image, when seen sharp and double in the telescope, will be just as distant from the object glass of the telescope as the latter has been adjusted for. The angle of the two images is read off on the micrometer in the eyepiece, and from the number obtained the diversion of the two rays after their passage through the triple prism is calculated. The ocular can now be provided with tourmaline and $\frac{1}{4}$ mica plate, which may be used singly or combined. The tourmaline alone shows, on turning, in all azimuths, the double image without alteration of intensity in the component parts; the two rays undergo, therefore, neither linear (plain) nor elliptical polarisation. The tourmaline with mica plate below it, shows, as well known, that both rays are circularly polarised, the one right, the other left; the tourmaline must in this case be so adjusted that its line of principal action be azimuth 0° or 90°, and the main section of the interposed mica plate is turned to form with that line $\pm 45°$.

The aim of the measurements is to determine the refractive indices of the two rays of opposite circular polarisation, propagated with unequal velocity along the optical axis of the quartz.

872. Stauroscope, according to the design of F. von Kobell, executed by Wiedemann.

Prof. Dr. Franz von Kobell, Munich.

873. Analysing Prism of **Iceland Spar,** made by the inventor, the late William Nicol, in his 80th year.

Edinburgh Museum of Science and Art.

The Nicol prism is so constructed that only one polarised ray can pass through it.

873a. Nicol's Prism for Polarising Light, by C. D. Ahrens. *W. Spottiswoode, F.R.S.*

This, which is one of the largest ever constructed, has a clear field of $3\frac{1}{4}$ inches in diameter. With a view to saving bulk and weight, the acute angles have been cut off, and the whole reduced to an octagonal form. The advantages of this will readily be seen by comparing this instrument with that by Tisley and Spiller, the field of which is greater by only a quarter of an inch.

873b. Nicol's Prism for Polarising Light, by Tisley and Spiller. *W. Spottiswoode, F.R.S.*

This, which is the largest and purest ever constructed, has a clear field of fully $3\frac{1}{2}$ inches in diameter.

874. Soleil-Ventzke Polarising Apparatus, with several improvements. *Franz Schmidt and Haensch, Berlin.*

Soleil having introduced compensation by the use of rock-crystal, Ventzke subsequently improved the colour-giving power, and Scheibler made further improvements, principally in the manner of inserting the observation tubes. Messrs. Schmidt and Haensch, besides a few minor changes, succeeded in making improvements which greatly facilitate the use of the instrument, by a change in the construction of the wedges, and have thus reduced the irregularities frequently observed in the polarisation of diluted solutions to from one to two tenths per cent. in each part of the scale. They have thereby done away with the principal cause of the variations which so frequently occur in the observations of different analysts.

875. Jellett-Corny Half-shade Polarising Apparatus, provided with wedge compensation.

Franz Schmidt and Haensch, Berlin.

This apparatus differs from the foregoing in having the double plate replaced by a double Nicol's prism. In using it both fields of the apparatus are adjusted to equal half darkness, instead of equal colour, as in the "Soleil. The double Nicol prism was first proposed by Professor Jelett, of Dublin, and employed by Professor Corny in Duboscq's polariscope for circular polarisation, known as saccharomètre à pénombre. The improvement in the instrument exhibited by Messrs. Schmidt and Haensch consists in combining with it their wedge-compensation, so as to obtain the advantage of lineal readings. The instrument recommends itself for dark solutions; it is indispensable for colour-blind operators, and prevents the colour-weariness to which the healthy eye is liable. Its sensitiveness perceptibly exceeds that of a Soleil.

876. Wild's Polari-Strobometer.

Franz Schmidt and Haensch, Berlin.

877. Jellett-Corny Polarising Apparatus, constructed for circular polarisation. *Franz Schmidt and Haensch, Berlin.*

877a. Handy Polariscope with Nicol prisms to show rings in bi-axial crystals. *W. Previte Orton.*

This instrument was designed by the exhibitor and made for him by Pastorelli. Its object is to utilize the Nicols of a small microscope so as to show the effect of polarised light in a biaxial crystal; and further, to do this in a handy manageable and inexpensive form.

878. Mica-preparations of mono- and bi- axial mica, for polariscopes. (See Mineralogy.) *Max. Raphael, Breslau.*

879. Mica-preparations of foliaceous mosses ("Laubmoosen"), Algal, &c., for microscopes. *Max. Raphael, Breslau.*

879a. Quartz Axis Plates. *M. Lutz, Paris.*

879b. Amethyst cut parallel to the axis. *M. Lutz, Paris.*

880. Dichroscopic Lens.

Four Nicol's prisms.
Prazmowski prism.
Two Tourmalines parallel to the axis.
Iceland spar of M. Bertrand's arrangement.
Quartz and mica for compensating the refraction of crystals.
Heated crystals, felspar, gypsum, carbonate of lead.
One blue glass, red glass, and green glass.
Billet lens on stand.

Laurent.

881. Ellipsometer. Before the eyepiece of the glass a double refracting prism is made to turn until a wire, moving perpendicularly to the principal section of the prism, passes through the two intersecting points of the two reflections of the ellipse. An index shows at the moment the position of the prism.

882. Table Polariscope, made by the exhibitor when a youth. *Rev. Nicholas Brady.*

The interest of this instrument consists in showing with what simple materials a student can construct a fairly useful apparatus, the divided circles being common stamped protractors; the clamping screws, teapot thumb-screws, and the mountings of the lenses ordinary simple microscope frames.

882a. Original Apparatus for Rotatory Polarization, by Biot. *College of France, Paris.*

883. Airy's Polariscope, with appliances for approximately measuring the angle between the planes of polarisation and analysation, and for determining the angle between the optic axes of bi-axal crystals in air or in a fluid medium. Modified and arranged by the contributor when a student. *Rev. Nicholas Brady, M.A.*

883a. Large Polariscope for Projection, by Ladd. *W. Spottiswoode, F.R.S.*

A pair of Nicol's prisms, by Ladd, the first of a large size ever constructed. They are furnished with a system of lenses for showing the crystal rings, as well as with other contrivances for the various phenomena of polarised light.

883b. Revolving Analyser for Polariscope, constructed by Tisley and Spiller. *W. Spottiswoode, F.R.S.*

A revolving analyser, consisting of a double image prism, furnished with wheel-work, whereby it may be caused to revolve with such rapidity that the eccentric image may remain upon the retina during a complete revolution, and thus give the appearance of a ring of light. By this means all the phases of polarised light as seen successively in ordinary polariscopes may be seen simultaneously. The instrument is adapted to show all the phenomena of chromatic polarisation, both plane and circular. An instrument for a similar purpose was invented independently by Prof. Machs, of Vienna.

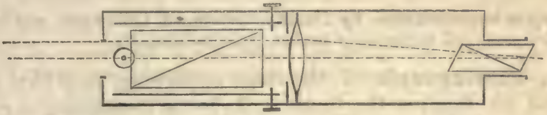
883c. Portable form of Polariscope, comprising a Nicol's prism, a double-image prism, a plate of tourmalin, a Savart's wedge, a bi-quartz, a dichroscope, and a quarter undulation plate. These various parts may be used either separately or in any combinations at pleasure; and are consequently adapted either to illustrate the general laws of polarised light, or for actual observations of atmospheric or other polarisation not involving actual measurements. It will be observed that the tourmalin plate gives the opportunity of using convergent as well as parallel light. The instrument is fitted in a case 2 inches long and $\frac{3}{4}$ inch in diameter, but its size might be considerably reduced below the dimensions of the specimen here exhibited. *Mrs. W. Spottiswoode.*

883cc. Spottiswoode's Pocket Polarising Apparatus, consisting of Nicol's prism, Savart's polariscope, tourmaline, double-image prism, bi-quartz, dichroscope, and $\frac{1}{4}$-undulation plate. The whole is packed in a leather case, 2 inches long, by $\frac{3}{4}$ inch in diameter. *W. Ladd & Co.*

883d. Large Circle for measuring the **Azimuths** of **Elliptic** and **Rotatory Polarisation**, and reproducing all experiments of polarisation and reflection.

School of Pharmacy, Paris.

883d. Polariscope for detecting faint traces of Polarisation independently of its direction. The wedges are right and left-handed quartz, with their axes parallel to that of the instrument. The eye should be placed in the focus of the lens, with the Nicol interposed. Designed by the exhibitor and made by Messrs. Tisley & Spiller. *R. H. M. Bosanquet.*



883e. Arago's Polariscope. *M. Lutz, Paris.*

883f. Savart's Polariscope. *M. Lutz, Paris.*

883g. Tourmaline Plates. *M. Lutz, Paris.*

883h. De Sénarmont's Polariscope. *M. Lutz, Paris.*

884. Wheatstone's Polar Clock. To determine the true solar time by the polarisation of light reflected from the sky.

The Council of King's College, London.

885. Latest form of Wheatstone's Polar Clock. To determine the true solar time by the polarisation of light reflected from the sky.

The Council of King's College, London.

Soleil's Compensator. *S. Laurent, Paris.*

887. Norremberg's Polarising Apparatus, with Wheatstone's improvements. *H. Lloyd, Trinity College, Dublin.*

888. Duboscq's Polariscope, for determining the inclination of the axes in bi-axial crystals.

H. Lloyd, Trinity College, Dublin.

889. Wheatstone's Apparatus to illustrate the laws of interference of polarised light.

H. Lloyd, Trinity College, Dublin.

889a. Ladd's Polariscope, consisting of a bundle of glass, selenite design, and Nicol's prism, &c. *W. Ladd & Co.*

2531. Photograph of a **Wild's Polari-strobometer,** for determining the rotation at different temperatures. The tube containing the liquid is surrounded by a jacket, through which water of a given temperature flows. The apparatus is manufactured by Messrs. Hermann and Pfister, Bonn.

Prof. H. Landolt, Aix-la-Chapelle.

2532. Photographs of a simple **Polari-strobometer** with two Nicol's prisms, constructed for holding tubes, one meter in length, containing the liquids which can be placed in a water-bath; and a blow-pipe lamp, over which is suspended a platinum gauze cage for holding the sodium salt which is used for producing the monochromatic sodium flame.

Prof. H. Landolt, Aix-la-Chapelle.

The lamp is manufactured by Dr. Meyerstein of Göttingen, and by Feldhausen, philosophical instrument maker, Aix-la-Chapelle.

2533. Photograph of the same apparatus, provided with a short tube for holding the liquid. A bottle containing a solution of potassium dichromate is interposed between the tube and the sodium flame, to ensure a purer monochromatic light.

Prof. H. Landolt, Aix-la-Chapelle.

III.—PHOTOMETERS.

891. Great Atmospheric Photometer. De la Rive model, designed by M. Thury, and constructed by the Geneva Association for the Construction of Scientific Instruments.

De la Rive Collection. The property of Messrs. Soret, Perrot, and Sarasin, Geneva.

This apparatus is particularly intended to measure the transparency of the atmosphere. It is used for simultaneous observation, with one eye, through two similar eyepieces of two similar objects placed at different distances. The difference of brightness and of tint between the two reflections indicates the effect of the intervening stratum of air. The computation of this difference is arrived at by equalising the two images by means of diaphragms of different aperture, and of glass plates variously tinted. The instrument is composed of a telescope with a single eyepiece, and two objective tubes, of which the angular distance can be varied between 0° and 29°. A system of four total reflection prisms unites the two divergent cones in the eyepiece. The apparatus is movable round three different axes, and may be worked in the most varied directions. Graduated circles measure these different angular motions. It is a general photometer, and can be specially used as an astronomical photometer. De la Rive has effected with it a long series of observations on the transparency of the air. (See Comptes Rendus, vol. 63, p. 1221.)

892. Photometer, according to Glan's system, for photometrical determination of the absorption spectra for homogeneous light. *Schmidt and Haensch, Berlin.*

892a. Photometer, fitted with clock, governor, pressure gauge, and all necessary apparatus complete, as adopted by the Government of Canada. *William Sugg.*

893. Photometer by **Bunsen,** simplified by Professor Bohn. *Physical Collection of the University of Giessen, Prof. Buff.*

The standard for comparison is a pure stearine candle of known weight. The measure wound upon the cylinder serves to determine the distance at which the oil spot on the paper, when viewed from the second flame, is made to disappear. First the standard candle, and then the flame, to be measured, are thus investigated. The intensities of the two lights are to one another as the squares of their distances from the oil spot.

894. Photometer, for ascertaining amount of daylight. *Scottish Meteorological Society.*

The light is reduced by turning round the graduated milled head at the side, which works simultaneously and by equal degrees the two shades which thus reduce the area of the aperture. At the opposite end of the box a printed page is looked at through the eye-piece till it ceases to be legible, when the result is read off in revolutions of the milled-head. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in Society's Journal, vol. iii., page 292.

895. Selenium Photometer. *Siemens and Halske, Berlin.*

It being the property of selenium that its electrical resistance is diminished by the action of light, the diminution being dependent on the intensity of the light, this apparatus is constructed with a plate of selenium forming part of an electric circuit which is brought by rotating the cylinder containing the plate alternately under the action of a normal candle sliding on a scale and of the light to be measured. The normal light is adjusted on the sliding scale until the electrical resistance of the selenium remains constant under the action of the two sources of light, and the intensity of the light to be measured is calculated from the relative distances of the lights from the selenium plate.

896. New Optometer, with double-refracting lens of calc-spar, giving double readings, and greater precision in determining the distance of sight. *Prof. Carl Wenzel Zenger, Prague.*

IV.—RADIOMETERS.

899. Collection of Radiometers of different construction, with lamps and screen for making experiments. *Prof. Adolph Weinhold, Chemnitz.*

The apparatus serves to perform the radiometer experiments, described by the exhibitor in *Carl's* "Repert. der Experimental Phys., 1876, Heft. 2." Compare also the description annexed to the apparatus.

900. New Radiometers. *Dr. H. Geissler, Bonn.*

901. Radiometer. *John Browning.*

These instruments are set in motion by either light or heat; they consist of four small discs on two arms at right angles to each other; the discs may be of pith or mica; those exhibited are made of mica, as they appear to be the most sensitive to minute traces of light. One side of each disc has a dead black surface. The action of light or heat repels the black surfaces, and continuous motion is obtained so long as any light or heat falls on them.

902. The late Prof. T. T. Müller's Apparatus for illustrating the influence of the intensity of light on its rapidity of propagation (Poggendorff's Annalen, 1872, cxlv. p. 86.)
Prof. A. Mousson, Zurich.

Use is made of Newton's rings, produced between a plane glass *a*, and another glass *b* (the latter very slightly convex), which may be separated in a known manner so as to produce differences of progression up to 50,000 waves. At this distance, the convex glass *b*, on which *a* rested at first, radiates in the centre of a square iron vessel *c* on mercury. The three screws of the support *d* which surrounds the glasses are fixed apart. Then, the mercury having been allowed to flow out (through the cock *b*), *c* is brought down and fixed also, by means of three other screws *y*. The distance can be calculated with great precision by means of the weight of the mercury, and the known area of the vessel *c*.

The luminous point used is the small image at the opening of a collimating tube *e*, lighted by a monochromatic sodium flame, upon the hypothenuse surface of a small prism *f*. From this point the rays diverge and fall on the lens *g*, placed on the glass *c*, which makes them parallel. These rays return, with interference, from the two reflecting faces, towards the point *f*, where the eye is placed close to the prism.

Now, if the intensity of the light be lessened by interposing absorbing glasses, it will be seen that the greater the difference in the number of waves the more the lines change place, the increase of rapidity being proportionate to that of intensity.

V.—REFLECTION, REFRACTION, AND DIFFRACTION.

903. Total Reflection Apparatus, for the projection of objects placed in a horizontal position.
J. and A. Molteni, Paris.

904. Small Prism for double reflection. *Laurent.*

905. Coloured Rings on an 80 millimetre tripod.
Laurent.

905a. Fresnel's Parallelopiped. *M. Lutz, Paris.*

908. Apparatus designed to exhibit Double Reflection, which arises when a ray of light traversing a uni-axial or bi-axial crystal reaches the surface of contact of the crystal with the surrounding medium. *Arthur Hill Curtis.*

The incident light passes through a small orifice in the cap terminating one of the tubes. If the eye be applied to the other tube, as the stage on which the crystal rests is turned round its vertical axis, four, three, or two images of the orifice will be seen formed by the two rays which, refracted at the upper surface, are (in general) *each* doubly reflected at the lower surface. A Nicol's prism is added, which, though not essential to viewing the phenomena, may be introduced into *either* tube to polarise the incident light, or to examine the planes of polarisation of the reflected rays.

I. Sphere of Calcite, $3\frac{3}{4}$ inches in diameter.

II. Polyhedron of Calcite, cut from a large rhombohedron of that mineral, so as to represent the optical characters of the crystal in directions perpendicular—

1. To the pinakoid, and along the optic axis.
2. To a prism plane, and perpendicular to the optic axis.
3. To the cleavage planes (of the rhombohedron) {100}.
4. To the plane $\{\bar{1}22\}$ correlative to the cleavage rhombohedron.

(These were made by Mr. Ahrens.) *Prof. N. S. Maskelyne.*

909. Dichroic Apparatus. *A. Hilger.*

910. Iceland Spar Prism, of 60°, showing single refraction for any line in the spectrum. *A. Hilger.*

910a. Two Nicol's Prisms. *South Kensington Museum.*

911. Prism, with Double Reflector, of Dr. de Wecker. Two triangular prisms are joined together at their hypothenuse; while the observer looks directly through the cube formed by the union of the two prisms, an observer looking obliquely sees in the hypothenuse the reflection of the former as though in a mirror. The lens serves to show the reflection smaller and reversed.
M. Crétès, Paris.

912. Prism, Movable, by Crétès. Two prisms of 15° each are placed in a setting. When placed base on edge, their refraction becomes annulled: $(15-15=0)$. When placed base to base, their effect becomes added: $(15+15=30)$. Between these two extremes, an ascending scale of 0 to 30° can be obtained. The prismatic axis remains fixed, because the glasses move equally in reverse ways. *M. Crétès, Paris.*

912a. Three Rectangular Prisms, crown glass.
M. Lutz, Paris.

912b. 32 Rectangular Prisms, flint glass of various sizes.
M. Lutz, Paris.

912c. Prisms for Camera. *M. Lutz, Paris.*

912d. Prisms with Compartments. *M. Lutz, Paris.*

912e. Prisms with Compartments. *M. Lutz, Paris.*

912f. Bi-refracting Spar Prisms. *M. Lutz, Paris.*

912g. Rhomboids of Spar. *M. Lutz, Paris.*

912h. Collection of 12 Nicol Prisms. *M. Lutz, Paris.*

912i. Four Large Nicol Prisms. *M. Lutz, Paris.*

912j. Prisms for M. Desain's Experiments. *M. Lutz, Paris.*

912k. Uranium Glass Prisms. *M. Lutz, Paris.*

912l. Uranium Glass Cube. *M. Lutz, Paris.*

912m. Three Quartz Prisms. *M. Lutz, Paris.*

912n. Prisms for Spectroscope (direct vision). *M. Lutz, Paris.*

912o. Prisms for Spectroscope (direct vision). *M. Lutz, Paris.*

912p. Two Pyramidal Prisms. *M. Lutz, Paris.*

912q. Three Flagon Prisms. *M. Lutz, Paris.*

912r. Four Polyprisms. *M. Lutz, Paris.*

912s. Four Prisms for Bisulphide of Carbon. *M. Lutz, Paris.*

912t. Two Isosceles Prisms of Flint Glass. *M. Lutz, Paris.*

912u. Three Foucault's Prisms. *M. Lutz, Paris.*

912v. Two De Sénamont's Prisms. *M. Lutz, Paris.*

912w. Three Braszinowski and Hartnack's Prisms. *M. Lutz, Paris.*

912x. Six Rochon's Prisms. *M. Lutz, Paris.*

912y. Boit's Prism. *M. Lutz, Paris.*

912z. Large Flint Glass Prism, extra denticulated, set in a peculiar manner. *M. Lutz, Paris.*

913. Instrument to show the phenomenon of conical refraction, with models of Fresnel's wave surface. (Soleil, Paris.) *H. Lloyd, Trinity College, Dublin.*

914. Jamin's Optical Bank of Diffraction.
H. Lloyd, Trinity College, Dublin.

914a. Jamin's Apparatus with Parallel Mirrors.
M. Lutz, Paris.

914b. Large Steel Mirror. *M. Lutz, Paris.*

914c. Series of Barton's Iris Buttons, consisting of gold and steel faces engraved upon which are numbers of very fine lines, illustrating most beautifully *iridescence* or decomposition of light from ruled surfaces. The lines on the large steel button are 100, 200, 400, 500, 1,000, 2,000, and 4,000 to the inch.
Robert C. Murray.

915. Optical Bank, improved by Professor Clifton, to observe the interference and diffraction of light and measure the bands. *Elliott Brothers.*

915b. Collection of Six Gratings (*réseaux*) by Nobert of Barth, and Steeg of Homburg. *Teyler Foundation, Haarlem.*

Nobert B. of 1,801 lines in six Paris lines.
„ C. of 3,001 „ „ „
„ D. of 10,801 „ in one Paris inch.
„ E. of 2,001 „ „ „
„ F. of 3,001 „ „ „
Steeg A. of 3,201 lines in five millimètres.

Nobert B and C were used by Prof. Van der Willigen for the determination of the wave-lengths of fifty lines in the solar spectrum.

915c. Specimens of **Circular Gratings** (*Réseaux*) photographed on **Glass.** The rays of the successive circles limiting the opaque and transparent parts are in the proportion of 1 to $\sqrt{2}$, $\sqrt{3}$, $\sqrt{4}$, $\sqrt{5}$, &c.

915d. Large **Circular Grating** on **smoked Glass,** transparent traces of equal width, having rays in the proportion of $\sqrt{3}$, $\sqrt{7}$, $\sqrt{11}$, $\sqrt{15}$, $\sqrt{19}$, &c. *J. Louis Soret, Geneva.*

See "Mémoire sur les Phénomènes de Diffraction produits par les Réseaux circulaires" (Archives des Sciences physiques et naturelles, 1875, Vol. 52, p. 320. Poggendorff's Annalen, 1875, No. 9).

915e. Telescope with Circular Gratings. Constructed by the Geneva Association for the Construction of Scientific Instruments. *J. Louis Soret, Geneva.*

1st arrangement. The smoked glass grating is used for objective with a common eyepiece. Looking at a gas jet (for instance) at seven metres distance, the distance of the objective and the eyepiece being from 34 to 41 centimetres, then pulling out one of the tubes the image of the jet is seen reversed, and coloured more or less. By pushing in the tube as much as possible, the second image is seen green-coloured.

2nd arrangement. A common objective is used, and for eyepiece the small photographic grating. The distance from the objective to the eyepiece being of 50 centimetres (maximum length of the telescope), the image of the gas jet, reversed, is obtained as in an astronomical glass. By pushing in the tube to 31 centimetres, the direct image' is got as in the Galileo telescope. (*See* Mémoire sur les Phénomènes de Diffraction produits par les Réseaux circulaires, Archives des Sciences physiques et naturelles, 1875, vol. 52, p. 320.)

915f. Diffraction Grating on speculum metal. *A. Hilger.*

916. Refractometer, according to **Abbe's** system, for determining the refractive indices, and the dispersion of any kind of liquids. *Carl Zeiss, Jena.*

The refractometer enables the determination of the refractive index of a liquid to be effected up to four decimals with a single drop of the substance. The readings refer to line D, and are read off from a graduated sector.

917. Procentum Refractometer, for determining the percentage of solutions and mixtures by optical means.

Carl Zeiss, Jena.

The instrument is designed for liquids whose index lies between 1·3 and 1·4. The determination takes place at a numbered scale in the field of view of a small telescope. Besides the scale for the absolute index of refraction, there is another scale, which gives directly the per-centage strength of saccharine liquor.

917a. Refractometer by M. Jamin.

Polytechnic School, Paris.

917b. Jamin's Interference Apparatus with two Spars. *M. Lutz.*

917c. Refraction Goniometer, constructed by the Rev. Baden Powell, and used in some of his experiments, and afterwards by the Rev. T. Pelham Dale and Dr. Gladstone in their earlier researches on refractive indices of liquids at different temperatures. *Mrs. Baden Powell.*

919. Abbe's Refractometer, for determining the power of refraction of different liquids as far as the fifth decimal, with direct reading of the refractive index, without calculation. (Comp. Abbe: "Neue Apparate.")

Franz Schmidt and Haensch, Berlin.

921. Apparatus on J. Müller's Principle, for Experiments on the Refraction of Rays of Light in Fluids.

Warmbrunn, Quilitz, and Co., Berlin.

921a. Apparatus by M. Mascart for studying the Refraction of Gas.

M. Mascart, Professor at the College of France.

921a. Drawing of the **Apparatus** used in 1842 by Prof. Daniel Colladon to show the total refraction of light in the interior of a vein of water. *See* Comptes Rendus, vol. 15, p. 800.

Prof. Daniel Colladon, Geneva.

This remarkable experiment was made on a large scale by the French Government on several occasions at public festivals.

921b. Apparatus for determining the Refractive Index of Solids and Liquids.

C. Czechovicz, Teacher of Physics at the Gymnasium, Belostok, Russia.

Consists of a horizontal board and vertical divided pillar with movable support for a telescope. The body under examination is put on a glass plane attached over a slit in the board, through which a light beam is reflected by an inclined mirror. A linear mark made on the upper surface of the glass (if the body is solid), or on the upper surface of the vessel (if the body is liquid), is brought in coincidence with a movable wire which touches the upper plane of the body. The distance of this wire and the height and inclination of the telescope give the necessary data for calculating the index with sufficient approximation.

VI.—FLUORESCENT BODIES.

922. Fluids showing the **Phenomenon** of **Fluorescence.**

Charles Horner.

A. Soda salt of anthracene in water.
B. Fluorescine in water.
C. Eosine in water.

923. Fluids showing the **Phenomenon** of **Fluorescence.**

Charles Horner.

Small Tubes in Stand.

D. Turmeric in castor oil.
E. Harmaline in water.
F. Magdala red in alcohol.
G. Ebony wood (*Amerimuum ebenus*) in castor oil.
H. Induline in chloroform.
I. Esculine in water.
K. Camwood (*Baphia nitida*) in castor oil.
L. Esculetine in water with alkali.
M. Fraxine (*Fraxinus excelsior*) in water.
N. Fustic (*Maclura tinctoria*) in solution of alum.

924. Selection of eight fluorescent liquids.

Dr. Th. Schuchardt, Görlitz.

Eosine.
Magdala Red.
Saffranine.
Fraxine.
Extract of Cuba-wood.
Aesculine.
Bichloranthracine.
Bisulphurous acid.

VII.—PHOTOGRAPHY.

a. PHOTOGRAPHIC PROCESSES.

925. Frame containing glass negative, gelatine "relief," leaden "mould," and impression from the latter, showing the various stages in the production of a "Woodbury" permanent photograph.

Woodbury Permanent Photographic Printing Company.

926. Frame containing transparencies for the magic lantern, printed by the "Woodbury" process.

Woodbury Permanent Photographic Printing Company.

927. Specimens of Willis's Aniline Process. Printed from tracings by Vincent Brooks, Day and Son.

William Willis.

This is a method of photographic printing differing greatly from all other kinds in the chemical actions involved and in the manipulations required. The blacks of the picture are produced by the action of aniline vapour on free chromic acid; the paper having been first coated with the latter substance, and exposed to light under the drawing to be copied. On placing this exposed sheet in a chamber filled with aniline vapour the yellow unaltered chromic acid becomes speedily blackened, and produces a permanent print. No negative is required, but a positive print is obtained by one operation from a positive original. The principal application of the process is the copying of engineers' and architects' tracings.

928. Willis's Platinum Printing Process.

Wm. Willis.

This is a method of photographic printing by which the picture is made to consist of platinum black instead of silver. The reduction of the platinum salt, with which the paper is coated, is effected by the action of light on a persalt of iron, which forms an additional coating to the paper, followed by a floating of the print on a solution of potassic oxalate.

928a. Illustrations of the Heliotype Process.

B. J. Edwards and Co.

The photographs are printed in printers' ink, at an ordinary printing press, from a film of gelatine, to which the photographic image has been transferred by the action of light.

1. Gelatine film ready for exposure to light under the negative.
2. Film laid down upon a metal plate and inked up ready for printing from.
3. Proof in permanent ink from the same film.

928b. Photograph Reproductions.

1. Embroidered stuff on velvet ground.
2. Faience dish, after Bernard Palissy.
3. Blue framed enamel, pâte tendre de Solon.
4. Louis XIV. shield, repoussé copper.
5. Incense-burners, silver filigree, enamel and stones.

6. Mirror, silver-gilt and precious stones.
7. Tobacco jar, gold and silver.
8. Holy-water vessel, Limoges enamel, with frame and precious stones.
9. Hunting knife handle, silver and stones.
10. Byzantine dish, repoussé copper.
11. Aliotide shell, from nature.
12. Cup, silver and rubies.
13. "The First Fable," after the oil painting by Simonetti (Salon de 1875).
14. "After Action," after the oil painting by Marchetti (Salon de 1875). *M. Léon Vidal, Paris.*

928c. Specimens of Dallastype. *D. C. Dallas.*

928d. Specimens of Dallastint. *D. C. Dallas.*

928e. Specimens of Chromo-Dallastint. *D. C. Dallas.*

928f. Specimens of Carbon transparencies. *Col. Stuart-Wortley.*

928g. "Cleopatra," a solar enlargement on salted paper, by R. Fenton, from a photograph of the original in the National Gallery. *Robert Sabine.*

928ee. Chromo-Woodbury Type, combination of Woodbury type with chromo-lithography. *Walter B. Woodbury.*

928ef. Kaleidoscopic Photograph of Ferns. *Walter B. Woodbury.*

928h. Seven Photographic Prints on Salted Paper, from Waxed Paper Negatives.

Two views of Windmill for reflecting stereoscope, by B. B. Turner.

Two views of the First Post on the road from Kief to Moscow by R. Fenton, for reflecting stereoscope.

Two views of a Russian Cottage, for reflecting stereoscope, by R. Fenton.

View of ruined Interior, by Le Gray. *Robert Sabine.*

928j. Two Sheets of Photographic Prints, by the Iron and Uranium process. M. Nièpce de St. Victor, 1857. *Robert Sabine.*

928k. Five Sheets of Photographic Prints, from waxed paper negatives on albumenized paper, by R. Fenton. *Robert Sabine.*

928l. Ten Photographic Prints from waxed paper negatives on albumenized paper, 1853. *Robert Sabine.*

928m. Two Sheets of Talbotype Prints from waxed paper negatives. *Robert Sabine.*

928n. Two Views for the Reflecting Stereoscope; the varnish used to render the prints transparent, having preserved the details of image from fading. *Robert Sabine.*

929. Specimens of Dujardin's photo-engraving process. *Dujardin, Paris.*

930. Specimens of Photo-type Printing on Zinc. *Capt. Abney, R.E., F.R.S.*

931. Gillot's Photo-type Process. *Veuve Gillot.*

932. First known Photograph on Glass, taken on precipitated silver chloride, by Sir J. Herschel (Slough, 1839.) *Prof. A. S. Herschel.*

"Having precipitated muriate of silver in a very delicately divided state from water very slightly muriated it was allowed to settle on a glass plate; after 48 hours it had formed a film thin enough to bear drawing the water off very slowly by a siphon, and drying. Having dried it I found that it was very little affected by light, but with washing with weak nitrate of silver and drying it became highly sensible. In this state I took a camera picture of the telescope on it. Hyposulph. soda then poured cautiously down washes away the muriate of silver, and leaves a beautiful delicate film of silver representing the picture. If then the other side of the glass be smoked and black varnished the effect is much resembling daguerreotype, being dark on white as in nature, and also right and left as in nature, and as if on polished silver."—*Sir J. Herschel* (MS. Journal of Experiments).

937b. Original Book of Experiments made by **Sir J. Herschel** on the **Metallic Salts** sensitive to **Light.** *Prof. A. S. Herschel.*

933. Second Daguerreotype Proof, obtained by Daguerre in 1839. *Conservatoire des Arts et Métiers, Paris.*

Lithographic Stone of Poiteven, with a proof on paper. *Conservatoire des Arts et Métiers, Paris.*

935. Photographs by Daguerre. *M. Fizeau, Paris.*

937. Specimens illustrating the History of Photography. *French Photographic Society, Paris.*

937a. Daguerreotype full-length Portrait, taken in Paris in **1840,** by special appointment, on the roof of a house in the open air, at 6 a.m. Exposure 20 minutes, in June sun. *James Martin.*

938. Instantaneous Photograph. Waves breaking on the shore of Britain in 1876. *James Martin.*

939. Engravings with the Aid of Photography. *MM. Goupil et Cie., Paris.*

Proofs obtained by impression with fatty ink on copper plates engraved by hand, the lines on which are obtained by means of a photographic negative, with the use of chemical substances sensitive to the action of light.

1. "Pollice verso," after the painting by Gérôme.
2. "L'eminence grise," do. do.
3. "Rembrant dans son atelier" (Rembrant in his studio), after the painting by Gérôme.
4. "Il Décamerone" (The Decameron), Sorbi.
5. "La rentrée au Convent" (The return to the Convent), Zamacois.
6. "Le premier coup de canon" (The first cannon shot), Berne, Bellewurt.
7. Part of the colonnade of the Louvre, from nature.
8. Reproduction of a mineralogical fragment, from nature.
9. Frame containing the two plates from which proofs Nos. 7 and 8 were printed.

940. Photographic Prints, in ink. *Thiel Ainé, Paris.*

Class the 1st.

1. Reproduction of water-colour painting—A cow, after Troyon.
2. „ chalk drawing—Park of the Marquis de Mégrigny, after Lalanne.
3. „ chalk drawing—An old courtyard at Colombes, after Lalanne.
4. „ oil painting—The Resurrection, after Lazerges.
5. „ chalk drawing—Borders of the Rhine at Mulhouse, after Niederhausen.
6. „ chalk drawing—Ruins of a temple, after Lalanne.
7. „ oil painting—Presenting the Bride, after de Boucherville.

Class the 2nd.

8. Reproduction of chalk drawing—In the park at Plombières, Vosges, after Allongé. (Salvon, 1875.)
9. „ of chalk drawing—Rocks and lake, after Appian.
10. „ from nature—Church of St. Augustin, Paris.
11. „ „ —Opera-house, Paris.
12. „ „ —Notre Dame, Paris.
13. „ of chalk drawing—Borders of the Lake of Arandon, after Appian.
14. „ of chalk drawing—Borders of a pond, after Allongé.

Class the 3rd.

15. Reproduction of terra-cotta—Marguerite with the jewels, after Carrier-Bellenze.
16. „ of oil painting—The imprisoned loves, after Chaplin.
17. „ from nature—Study of foreground, stereotyped on paper of Mr. H. Le Secq.
18 „ from nature—Cathedral of Rheims, stereotyped on paper of Mr. H. Le Secq.
19. „ of chalk drawing—The Bois de Boulogne, after Lalanne.
20. „ from nature—Cathedral of Rheims, stereotyped on paper of Mr. Le Secq.
21. „ from nature—Study of foreground, stereotyped on paper of Mr. Le Secq.
22. „ of oil painting—The death of Asala.
23. „ of drawing—Head of Christ, after Lazergues.

CLASS THE 4TH.

24. Reproduction of oil painting—Diana's toilet, after Devedeux. (Imitation of photography with salts of silver.)
25. ,, from nature—A hawk; still life. (Imitation of photography with salts of silver.)
26. ,, from nature—Sèvres vases. (Imitation of photography with salts of silver.)
27. ,, from nature—Naumachy in the Park Monceaux. (Imitation of photography with salts of silver.)
28. ,, of chalk drawing—The borders of the Yères, after Allongé.
29. ,, from nature—The bridge of Solférino, Paris. (Imitation of photography with salts of silver.)
30. ,, from nature—Sèvres vases. (Imitation of photography with salts of silver.)
31. ,, of a print—Musings, after de Moussy.
32. ,, of terra-cotta—The Mountebank's, after Deca.

943. Photo-lithography Process of Simonan and Toovey.

Veuve Simonan and Toovey.

1. Plan of the town of Liège.
2. Portrait of Archbishop St. Lambert, after an old engraving.
3–7. Topographical plans, photographed by Capt. Hanot.
8–13. Six drawings of the "Campagnie des bronzes" at Bruxelles.
14–15. Two reproductions from a line drawing by Licot de Nivelles.
16–19. Four archæological drawings.
20. Frontispiece of an ancient MS.

This is a photo-lithographic process, and depends on the fact that if gum be mixed with potassium dichromate, and when dry be exposed to the action of light, it becomes insoluble. A paper is coated with gum and potassium dichromate, and exposed under the negative of a line subject, or under an etching on glass, having a non-actinic ground. When light has sufficiently acted, the paper which has a faint impression of the lines is placed under a pile of damped paper on the surface of a polished lithographic stone, and submitted to pressure for about an hour. The paper is then removed from the surface of the stone, the insoluble part forming the lines coming away with it. The lines of the engraving are thus left ungummed on the stone. A little olive oil is brushed over the surface, when the gum on the stone has been allowed to dry in a dark room. The surface is next washed, which dissolves away the gum, leaving the lines of the picture only. The stone is then rolled up with a lithographic roller, and is ready for giving impressions.

944. Specimens of Paul Pretsch's Photo-typography.

Warren De La Rue, F.R.S.

945. Electro-chemical Process for reproducing lithographic impressions on copper.

M. Erhard.

A proof freshly pulled from an autograph, lithograph, auto-lithograph, or a copper-plate which is intended to be reproduced, is, by this process, transferred to a copper-plate, and furnishes in a few minutes an intaglio copy of the plate, as clean and good as the original, which is in no wise injured by the operation.

By means of this process: firstly, it is unnecessary to preserve the cumbrous and fragile lithographic stones; secondly, a plate in use may be reproduced so as to ensure repeated impressions; thirdly, corrections may be made on the copper, which could not be made on the original plate, worn by repeated working. The cost of reproduction on copper by Erhard's process is small, and may be estimated at about 3 to 5 centimes per square centimetre.

1. Album containing 36 maps and plans reproduced by this electro-chemical process.
2. 10 copper plates obtained by this process, the impressions from which are shown in the album.

946. Photoglyphic engravings, 1853.
H. Fox Talbot, F.R.S.

947. Silver prints of views in **Knoll Park.**
School of Military Engineering, Chatham.

947a. Proof by Papyrotype Process.
School of Military Engineering, Chatham.

947b. Specimens of Enlarging Process.
School of Military Engineering, Chatham.

948. Second Proof of Photographic Engraving, obtained by M. Fizeau, without retouching, in 1843, and printed in greasy ink. *M. Fizeau, Paris.*

949. Daguerreotype Proof, fixed by M. Fizeau's process with chloride of gold, by Hubert, in 1840. *M. Fizeau, Paris.*

949a. Daguerrean Print, obtained by the continuous action of red rays, without mercury. *M. E. Becquerel.*

950. Photochromic Proofs (selection). *M. Vidal, Paris.*

951. Early Talbotypes.
The Council of King's College, London.

951a. Specimens of Enamel Process. *Wm. Mayland.*

952. Table of Specimens of Historical Records of Photography. *French Photographic Society.*

952a. Application of Photography to Cartography.
The Topographical Department of the Imperial Russian General Staff, St. Petersburg.

In the application of the negative process, Rupell's drying system, with tannin, has been employed. The positive prints are either black silver copies or blue iron pictures: preference is given to the latter if the photograph is to be traced over with Indian ink, and the photographical ground to be removed afterwards by etching for the purpose of producing a clean drawing.

1. Reproductions of Central Asiatic surveys and maps.
2. Copies of plates of survey sheets in European Russia.

952b. Photolithography.

The Topographical Department of the Imperial Russian General Staff, St. Petersburg.

Transfer on stone of a printing picture, well covered with ink, which has been produced on a gelatine ground rendered primarily sensitive by double chromate of potash.

Reproduction of a Hebrew manuscript of the 10th century, belonging to the Imperial Russian Public Library.

952c. Helio-Engraving. Sediment of galvanic copper on a photographical gelatine relief.

The Topographical Department of the Imperial Russian General Staff, St. Petersburg.

Copies of a heliographical edition of the survey of Bessarabia, on the scales of 1 : 100,000, and 1 : 126,000, and the survey of Finnland, scale, 1 : 42,000; map of Khiva, scale, 1 : 580,000, transferred on stone, and prepared as colour print.

952d. Examples of Heliographic and other Processes.

Imperial Establishment for the preparation of official papers, St. Petersburg.

1. Portfolio of heliographic copper-plate and mezzo-tint engravings by the process of G. Scamoni (manager of the Heliographic Department of the Establishment), containing :—

    27 reproductions of historical portraits ;
    10 reproductions of fine engravings ;
    12 reproductions of etchings ;
    8 reproductions of drawings executed with pen and ink, water-colour, and crayon ;
    17 reproductions of pen and ink drawings ;
    6 reproductions of wood engravings.

2. Heliographic plate in electrotyped copper.
3. Heliographic plate in electrotyped iron.
4. Typographic printing form in electrotyped iron, from type.
5. Typographic printing form in electrotyped iron, net-work from type.
6. Typographic printing form in electrotyped iron, net-work from relief.
7. Typographic printing form in electrotyped iron, guilloched net-work.
8. Typographic printing form in electrotyped iron, id-annealed.
9. Glass plate, with the surface irregularly broken up into floral and other forms through a coating of gelatine ($\frac{1}{2}$ millimeter thick), springing up from it when dried at a temperature of about 70° C., thereby producing a form from which an inimitable printing-plate can be made.
10. Handbook of heliography, by G. Scamoni.

b. PHOTOGRAPHIC APPARATUS.

953. Photographic Lenses for Landscape, Architecture, and Copying, showing progressive improvements from the original single meniscus lens :—

(*a.*) Single meniscus lens, used from 1851 to 1861.

(*b.*) Triplet, consisting of front combination. Double convex crown and plane concave flint; middle combination.

Double convex crown and double concave flint; back combination. Double concave flint, and double convex crown. Used from 1861 to 1864.

(*c.*) Doublet, consisting of front combination. Double convex crown and double convex flint; back combination, meniscus crown and concavo-convex flint. Used from 1864 to 1874.

(*d.*) Symmetrical lens, introduced in 1874, and consisting of front combination. Concavo-convex and meniscus lenses; back combination, exactly similar, the denser element being on the outside in both cases. *Ross & Co.*

954. Photographic Lenses for Portraiture, showing the progressive improvements from 1839 to present date:—

(*a.*) Original compound portrait lens. The first lens made in England by Andrew Ross for daguerreotype portraiture in 1839.

(*b.*) Compound portrait lens, with Waterhouse diaphragms, in front. Date 1851.

(*c.*) Compound portrait lens, with Waterhouse diaphragms, giving a flat field. Date 1858.

(*d.*) Compound portrait and group lens, giving a flat field, and straight marginal lines. Date 1874. *Ross & Co.*

954a. New Tourists' Photographic Apparatus for taking Wet Plates without the use of Dark Tent, all baths and chemicals being placed in water-tight compartments under body of camera. *Harvey, Reynolds, and Company.*

954b. Photographic Lens with which the pictures of Mr. Fox Talbot's Pencil of Nature were taken. (This is the first publication of photographs printed from negatives on paper.) Presented. *B. B. Turner.*

955. Photographic Apparatus. "Poor man's photography," for wet collodion negatives of the smallest possible size, but rapid and well defined. Twelve examples of negatives, 1 inch square, two framed and magnified positive copies, and the bath-holder in which these negatives were taken.

Prof. Piazzi Smyth.

These negatives are on microscope slide glasses, and were taken with a lens of rather less than 2 inch solar focus by Professor Piazzi Smyth, in Egypt, in 1865. They represent scenes inside the Great Pyramid by magnesium light, and outside it by daylight, including, in one of them, camels in motion. The two positive copies on glass, each 10 in. high, are exhibited to show to what extent magnifying may be carried without definition being lost to any sensible degree.

The peculiar bath-holder in which the small negatives were taken is also shown. It has been described in the "British Journal of Photography," in 1866, with improvements, in the almanacs of the same journal for 1874 and 1876.

955a. Photographic Apparatus, by M. A. Chevalier, for plan-drawing. *M. J. Duboscq, Paris.*

956. Lichtpaus Apparatus, for photographing maps, plans, &c. *Romain Talbot, Berlin.*

957. Press used in printing a "Woodbury" permanent photograph, with leaden mould in position.
Woodbury Permanent Photographic Printing Company.

958. Photographic Portrait Camera, D.
Voigtländer and Son (Chevalier von Voigtländer), Brunswick.

958a. Photographic Portrait Camera, No. 3.
Voigtländer and Son (Chevalier von Voigtländer), Brunswick.

959. Photographic Lens for Astronomical Photography. *John Henry Dallmeyer.*

A double combination lens (rapid rectilinear) of 4″ diameter and 30″ focal length, consisting of two symmetrical combinations, each having a focus of 63″, and composed respectively of a crown and flint-glass lens, united by a permanently transparent cement to avoid reflection at the contact surfaces. The flint lens occupies the exterior position in each combination. It is concavo-convex, convex side external. The crown lens is a meniscus, the convex side of the same radius of curvature as the flint lens.

The radii of curvatures are so apportioned between the lenses that the spherical, and chromatic, aberrations are destroyed; or, in other words, the combination is aplanatic, and this for aperture $\frac{f}{7}$ to $\frac{f}{8}$.

The lens described (one of a series) was constructed and used for photographing the sun's corona.

959a. Photographic Lens for Self-Recording Instruments, *i.e.*, Barographs, Thermographs, &c.
John Henry Dallmeyer.

A double combination lens (No. 2 C) of $2\frac{3}{4}$″ diameter and $4\frac{1}{2}$″ focus. It consists of a cemented front and an open back-combination, having a large angular aperture, *i.e.*, possessing great intensity. The front, or cemented combination, is composed of a double convex crown lens, of unequal curvatures, the shallow side occupying the outer position; and a double concave flint lens is united to the deep side of the crown, the adjacent surfaces being identical. At an interval equal to the diameter of the front is placed the back combination, composed of a concavo-convex flint lens, convex side facing the front combination, and a crown lens nearly plano-convex, with the more convex side nearest the flint lens, but of different radii of curvature, and therefore not cemented.

The ratio of foci between the front and back combinations is 2:3 nearly, and the radii of curvatures are calculated to produce well defined images for aperture $= \frac{f}{2}$, and angle of picture = 30°.

959b. Photographic Lenses for the reproduction of maps, plans, &c., as employed at the Home and Foreign Government Topographical Establishments. *John Henry Dallmeyer.*

1. A triple achromatic lens of 18″ focal length for copying on plates 15″ × 12″. As its name implies, this lens consists of three achromatic, or actinic, combinations, two of which, *i.e.* the front and back, are positive or converging lenses, and a negative or diverging lens placed between them. The positive combinations, the front of 2″ and the back of 3″ diameter respectively, with focal lengths of similar proportion, are composed each of a double convex crown, and a plano-concave flint-glass, lens; the adjacent surfaces being identical and cemented. The convex or crown lenses occupy the external position in both, and the combinations are separated by an interval equal to the diameter of the largest or posterior lens. Between the two, and proportionate to their diameters or foci, is placed the diaphragm aperture, or stop; this is also the position of the negative achromatic combination 1½″ diameter, the crown of which is in this case a double concave, and the flint a plano convex nearly. This combination limits the aperture to $\frac{f}{10}$; it does not affect the *direction* of the pencils as refracted by the front and back positive combinations, which produce an image free from distortion, though too much curved to admit of its reception on a flat screen; but its action (that of central pencils only) is confined to the proportionately greater prolongation of the oblique or marginal pencils, in virtue of its negative or divergent power. In other words, it lengthens these pencils and produces the required amount of flatness of field, the *sine quâ non* for copying purposes.

This lens, one of a series, was introduced in 1860, and is reported upon by the jurors of the International Exhibition of 1862: "As the first aplanatic "non-distorting view lens placed within the reach of photographers, and the "best lens extant for copying purposes, &c." It was first used in the Ordnance Survey Office at Southampton.

2. A 3″ symmetrical combination of 24″ focal length for plates 18″ × 16″. This lens, constructed for copying, consists of two combinations identical in all respects; each has a focal length of 46″, and is composed of a convexo-concave flint, and a convexo-concave or meniscus crown-glass lens; the radii of curvatures of the concave of the one and the convex of the other are identical and they are cemented.

The combinations, with their convex or flint elements external, are mounted in a tube a given distance apart, in this case about $\frac{1}{7}$ of the compound focal length, and midway between them is a perforation for the insertion of diaphragms or stops. Both combinations being identical in form and focal length, the direction of the finally emergent pencils is parallel to the incident ones; hence the lens is free from distortion.

Flatness of field and correction of aberrations are obtained, for the qualities of glass employed, by the forms and foci of the component elements, and in order to suit particular requirements the construction is modified for varying angular apertures of from $\frac{f}{4}$ to $\frac{f}{10}$, including proportionate angles of pictures of from 35° to 90°. This lens was introduced in 1866.

960. Photographic Lenses for Portraits and Views.

John Henry Dallmeyer.

1. & 2. These portrait lenses, introduced in 1866, are constructed on a new formula, as compared with the first portrait lens, the invention of Professor Petzval of Vienna, and which appeared in 1841.

Unlike the lenses used for astronomical photography, copying, &c., required to produce a sharp image of an object situated in *one* plane, and necessitating perfect correction for aberration, a portrait lens must produce a presentable picture of the human face, head, and body, situated in *different* planes; or possess what is called "depth of focus." A *perfectly corrected lens*, of sufficient angular aperture or rapidity of action to make portraiture possible, has no "depth of focus." An instrument, possessing a certain residual amount of spherical aberration, solves the difficulty to some extent. Unfortunately, however, a lens so constructed works at its best only for a given size of image or distance of object. If this be removed to a greater distance, as for a smaller image, the aberration is in excess, and if placed nearer, the converse obtains.

The lens now to be described surmounts this difficulty. Its aberrations, both spherical and chromatic, are perfectly corrected when used intact, or as sent out by the maker; and by the simple turn of a screw, separating the component elements of the posterior combination, this correction can be modified at will, *i.e.* positive spherical aberration, or "depth of focus," is obtained, proportionate in amount to the separation of the posterior lenses.

The front combination, composed of a double convex crown, and a double concave flint glass lens, is cemented, to prevent loss of light from reflection. The convex or crown lens occupies the exterior position. At a distance equal to the diameter of the front is placed the back combination; an uncemented compound of the same diameter as the front, but of greater focal length, *i.e.* as 2 : 3. The crown element of the back combination is a meniscus with its concave surface facing the front combination. The flint is concavo-convex, the convex side external; this lens is mounted in a cell, the screw of which affords the means of approach to, or separation from, the companion crown lens. An index and division registers the amount of separation.

The converging cone of rays refracted by the front is incident upon the crown element of the back combination; on emergence it is more strongly convergent when it meets the concave surface of the posterior flint lens. It is evident that any alteration in position or distance at once reduces or increases its effective diameter, or, in other words, its aberration (y^2). The aberrations being perfectly corrected when the posterior flint lens is screwed home, the index pointing zero, the smallest amount of unscrewing or increased separation at once introduces positive spherical aberration.

In Petzval's lens the position of the lenses composing the back combination is the reverse of the above; *i.e.* the flint, or convexo-concave element, faces the front combination, the rays when refracted by it are parallel or nearly so, and any alteration of distance of the companion crown lens is without effect upon the state of aberration of the objective as a whole.

The portrait lens constructed on the new formula is free from disturbing reflex images; it produces pictures approximately free from distortion, and illuminates a larger angle of field. It is made of three descriptions: viz. the A series, aperture $=\frac{f}{4}$, B $=\frac{f}{3}$, and D $=\frac{f}{6}$.

3. A single combination landscape lens of 2″ diameter and 12″ focal length for pictures on plates 12″ × 10″. It is composed of three lenses, two of which are of crown glass, but of different optical properties, and between these two is the correcting flint glass lens. The crown lenses are deep menisci, ratio of foci of front to back as 1 : 3; the flint is concavo-convex. The adjacent surfaces of the crowns and flint being identical they are cemented, and externally the combination is a deep concavo-convex, the concave side facing the view or landscape. Its aperture is limited by a diaphragm plate placed at a distance of $\frac{1}{7}$ the focal length in front of the lens; the stops provide apertures from $\frac{f}{12}$ to $\frac{f}{40}$. Correction of chromatic and spherical aberration is obtained by the foci and forms of the lenses employed.

The angle of picture included exceeds of 70°, and though marginal distortion of image is not entirely avoided, it is perhaps counterbalanced by the increased brilliancy of image and equality of illumination, due to the absence of all disturbing reflex images.

4. A wide angle rectilinear lens of $1\frac{1}{2}''$ diameter, and $7''$ equivalent focal length for $12'' \times 10''$ pictures.

This lens is constructed upon the same general principle as the symmetrical $3''$ combination already described, with this difference, that the lenses composing it, though similar in form, are of proportionately smaller diameter, *i.e.*, they are thinner, and being placed nearer together, they transmit more oblique pencils, and a larger angle of picture is included, as much as 90°, with apertures $\frac{f}{10}$ to $\frac{f}{40}$.

This instrument is designed for photographing objects in confined situations, such as interiors of buildings, monuments, &c., where the camera cannot be removed to more than a given distance. It produces images free from distortion and flare.

962a. Apparatus for producing photographs in permanent pigments ; consisting of,—

Registering pressure frame.

Plates of zinc, porcelain and opal glass (the plates having upon them : *a.* The sensitive tissue ready for development. *b.* The supporting paper stripped off. *c.* The picture partly developed. *d.* The picture ready for transfer).

Reservoir for hot water, with means of keeping it warm, and grooves for the plates.

Zinc trays for development washing, &c.

Wooden stool and squeezer for the mounting of the exposed sensitive tissue. *The Autotype Company.*

If a negative in half-tones be placed under a paper coated with gelatine pigments of any kind, and potassium dichromate, and then be exposed to light, the gelatinous film is rendered insoluble, to depths varying according to the intensity of the light passing through the various portions of the negative. If the paper were at this stage exposed to the action of hot water, it would be found that the soluble portions lay between the exterior surface of the film and the inner surface of the paper. In order to develop the picture, it is transferred by simple atmospheric pressure to a zinc plate or other temporary and impervious support. The original paper peels off, and the development takes place by the simple application of hot water, the shades of the image being formed of different thickness of gelatine and pigment. The image may be retransferred from the temporary support, or if developed on a paper support may be left as it is, in which case, unless the negative be reversed, the picture will appear reversed.

962c. Sir John Herschel's Actinometer, by Robinson, marked I and K.

The Meteorological Committee of the Royal Society.

977a. Actinometer. *Prof. Balfour Stewart.*

962b. Actinometers, or instruments for ascertaining the intensity of the action of the light, and by which the exposure of the sensitive pigment paper under the negative is regulated.

Johnson's, Vogel's, Spencer's, Lambert's, Sawyer's, Burton's, Vidal's. *The Autotype Company.*

OF THE

Chemicals Employed.

Granulated bichromate of potash. Chrome alum.

Colours.

Indian ink, vegetable black, Paris black, plumbago, Indian red, Venetian red, vermillion, purple madder, brown madder. vandyke brown, indigo, lac de vin, various kinds of gelatines.

962c. Pigmented Papers, in various colours, with subjects printed to show the various shades.

962d. Transfer Papers (*i.e.*, papers prepared with insoluble gelatine, and upon which the pictures finally rest).

962e. Sawyer's Patent Flexible Support (being paper prepared with insoluble gelatine and an aqueous solution of lac, upon which the picture is first developed previously to its transfer to the final support. *The Autotype Company.*

962f. Reversing Mirror, being a piece of plate glass polished to a perfectly true plane, and silvered by a chemical process used to produce *reversed* negatives, enabling them to be printed by the single transfer process of permanent pigment printing. *The Autotype Company.*

962g. Wave Bath, for nitrate of silver solution (being a new and convenient form for sensitizing large plates with a comparatively small quantity of solution. *The Autotype Company.*

962h. Sawyer's Collotype Process.
The Autotype Company.

Glass plates prepared with gelatine and isinglass, potassium dichromate, &c., hardened by a spirituous extract of gum resins, upon which the photograph is impressed by the action of light; after which they are placed in a type printing press, damped, and inked by lithographic rollers.

(*a.*) Plate in first stage of preparation.
(*b.*) Plate ready for exposure under negative.
(*c.*) Plate after exposure under negative.
(*d.*) Plate after being inked up in the press.
(*e.*) Plate with the same picture partly showing on the paper and partly on the plate.

988i. Four Prints from Photographs, by Paul Pretsch's mechanical process. *Robert Sabine.*

VIII.—EDUCATIONAL.

963. Frame with 163 Photographs on Glass, for projection by the lantern, for instruction in the natural sciences. *Romain Talbot, Berlin.*

964. Four simple Models, for instruction in the use of the telescope and the microscope.

J. Wilhelm Albert, Frankfort-on-Maine.

The four models for optical instruction are open instruments with lenses and shades. They show the course of the rays and illustrate in a simple manner the Galilean, astronomical, and terrestrial telescopes, and the compound microscope.

These models are largely used in German and foreign educational institutions.

964a. Sciopticon and three Manuals.

W. B. Woodbury.

965. Coloured Chalks for lectures, with a Black Board.

C. Blattner, Munich.

966. Interference Apparatus by Fresnel, executed for educational purposes by Ch. Jung, Giessen.

Physical Collection of the University of Giessen, Prof. Buff.

918. Apparatus for demonstrating the **Refraction of Light** in liquids, according to J. Müller.

J. Wilhelm Albert, Frankfort-on-Maine.

The semicircular plate of the refraction apparatus is of glass, ground on its outside and having the scale burnt into it in black. The ray refracted from the liquid appears therefore on the outside of the graduated plate and can thus be viewed by large audiences.

967. Educational Apparatus, for elementary experiments on **Refraction.** *Prof. Dr. J. J. Oppel, Frankfort-on-Maine.*

This apparatus is only a modification of the old experiment of viewing a coin at the bottom of a basin full of water. The coin is replaced by a white line upon black ground, and the water by a movable cube of glass. The position of the eye is fixed by a dioptric plate.

968. Educational Apparatus for illustrating **astronomical refraction** and its effect on measured heights of stars.

Prof. Dr. J. J. Oppel, Frankfort-on-Maine.

The eye looks through a dioptric plate over a wooden globe ("earth") towards a few stars and the rising moon, which appears above or below the horizon, according as the piece of glass, which represents the refracting atmosphere, is lifted up or removed by means of a contrivance attached to it.

969. Two Colour-tables, for illustrating "colour blindness," with greenish glass (absorbing the ends of the spectrum) belonging to them. *Prof. Dr. J. J. Oppel, Frankfort-on-Maine.*

Both tables, each with 10–12 colour-couples upon black ground, have reference to the most frequent form of achromatopsy, the so-called *red,* and *green,* blindness. The one table contains colour-couples which are most generally mistaken for one another; the other those that are never mistaken. The green glass, added to the tables, enables a normal eye to get an idea of that peculiarity of vision.

970. Apparatus for illustrating the Colours of double refracting Bodies, in the form of a Gothic window, composed of gypsum plates systematically arranged according to the colours; with a blackened glass plate belonging to it.

Prof. Dr. J. J. Oppel, Frankfort-on-Maine.

971. Some characteristic Drawings for illustrating the **Stroboscopical Principle,** with manifold movements, as,—forwards and backwards, centripetal and centrifugal, undulatory, oscillatory, and quite irregular.

Prof. Dr. J. J. Oppel, Frankfort-on-Maine.

Is a collection of those principal forms of periodic movements which can be represented stroboscopically.

IX.—MISCELLANEOUS.

897. First Heliostat, invented by 'sGravesande.

Prof. Dr. P. L. Rijke, Leyden.

(*See* 'sGravesande's "Physices Elementa Mathematica," ed. III., Tom. I., page 715.) 'sGravesande was an eminent Dutch geometrician, b. 1688, d. 1742.

898. Heliostat, G. Johnstone Stoney's modification, made by Spencer and Sons, Dublin, a cheap and useful form.

Prof. W. F. Barrett.

971aa. Self-adjusting Heliostat, mounted on a declination bar magnet. *Dr. Stone.*

971ab. Mounted Prism of Quartz. *Dr. Stone.*

971ac. Mounted Prism of Iceland Spar. *Dr. Stone.*

971ad. Equatorial Heliostat for maintaining a reflected beam of solar light in a constant position, applicable to places whose aspect will admit of a beam of light from the north only being obtained.

By changing the dial wheel of the clock, it may be used from the south as a polar instrument. *Conrad W. Cooke.*

It consists of a plane mirror, adjustable in declination, revolving upon a polar axis and driven by a clock. The clock has two interchangeable dial wheels whose circumferences are respectively one-half and one-fourth that of the wheel upon the polar axis of the mirror. By using the smaller, the mirror is driven round once in 48 hours, and if the instrument be placed due north of the spot to which the reflected beam is to be directed, and in the same equatorial plane with it, and adjusted in declination, the beam will be maintained in that plane and in a fixed meridional direction.

By substituting the larger dial, the mirror will rotate once in 24 hours, and if the instrument be placed due south and in such a position that its polar axis passes through the spot to be illuminated, the beam will be equally constant in direction from the south.

Heliostat and glass prism. *Prof. A. S. Herschel.*

971a. Wheatstone's Apparatus. *Paris Observatory.*

971b. Interferential Apparatus, by Arago.
Paris Observatory.

3699. Reflecting Stephanoscope.
Prof. Dr. Lommel, Erlangen.

(1.) The little apparatus is intended for the observation of interference phenomena produced by a dimmed (trübe) mirror. The mirror is at one end of a short brass tube, which has a lateral excision, and contains a second tube, whose one end is cut off at an angle of 45° to the axis, and is there closed with a plane glass. If the light of a candle is allowed to fall through the lateral apertures upon the plane glass, so that it is reflected vertically to the mirror, it will, on being viewed through the tubes, appear surrounded by *Newton's* rings, which pass, when the tube is slightly inclined, into the so-called *Whewell's* bands. If a pencil of solar rays is caused to enter by the lateral opening, and a lens of large focus is put on to the end of the second tube, the above images can be thrown upon a screen.

3700. Erythroscope. *Prof. Dr. Lommel, Erlangen.*

The erythroscope is an eye-glass of combined blue cobalt glass with red copper-suboxide glass, which gives passage only to the ultra red before line B. Since chlorophyll does not absorb this colour, the green parts of a plant appear, when viewed through the erythroscope, quite light coloured; the foliage of a tree in sunshine, for instance, will appear as light as a white cloud, and form a light spot upon the dark ground of the sky.

3701. Melanoscope. *Prof. Dr. Lommel, Erlangen.*

The melanoscope, a combination of dark red copper glass and light violet glass, allows chiefly the red rays between B and C to pass, which are absorbed with avidity by plants. Viewed therefore through the melanoscope plants will look very dark, almost black. This contrivance and the preceding one show in an instructive manner that plants absorb eagerly the middle portion of the red part of the spectrum, but not at all the ultra red.

3702. Erythrophytoscope I.
Prof. Dr. Lommel, Erlangen.

This combination of *Simmler*, consisting of blue cobalt glass and dark yellow iron oxide glass, transmits ultra red up to B, and also to yellow-green, blue-green, and blue. Leaves, looked upon through it, appear coral red, the sky blue, the cloud reddish-violet, the soil violet-grey.

3703. Erythrophytoscope II.
Prof. Dr. Lommel, Erlangen.

The erythrophytoscope II., combined of blue cobalt and light red copper glass, allows, besides ultra red, only blue-green and blue to pass. The effect is similar to that of the preceding combination, only more striking.

It should be remarked that, only vegetable and anilin green appear, as described under these combined glasses; mineral green would look dark blue-green.

3704. Coloured Gelatine Leaflets as objects for the spectroscope. *Prof. Dr. Lommel, Erlangen.*

To demonstrate the absorption phenomena of soluble colouring matters, plates of isinglass, which had been dyed with the colouring matter, are recommended, instead of the solutions. To protect these plates against dust, &c., they may be placed between two glass plates. By placing feebly coloured plates in a fan-shaped way upon one another, the increase of absorption by increasing thickness may easily be illustrated.

972. Mixoscope (colour-mixer), executed according to the directions of the exhibitor by M. Ph. Edelmann, Munich.

Prof. W. von Bezold, Royal Polytechnic School, Munich.

This apparatus gives the true colour resulting from the combination of two colours by actual trial with the brush, and thus a correct colour table can, by its means, be made with greater facility than with the revolving disc. The achromatised calcspar prism is so to be adjusted that on looking through the apparatus only six squares should be visible. It is easy to find this position through moving the telescope and turning the prism. On bringing the two colours to be mixed under two of the square openings, these colours will be right and left of the mixed colour, which fills the middle part of the three contiguous squares. If, now, the other two apertures contain the true optical compound colour, the two central squares will appear in the same tint.

Compare the description annexed to the apparatus.

973. Clockwork for colour discs, for lecture purposes, according to Kühne's and Becker's principles.

Rud. Jung, Heidelberg.

The clockwork, provided with a strong spring, is capable of rotating coloured discs of 28 centim. diameter with such velocity that a disc covered with the tints of the spectrum will appear white. By a simple contrivance the one or the other of the spectrum colours can be excluded, and thus its complementary and contrast colour produced. By inserting a second axle, the movements of the clockwork can be retarded.

1065a. Colorimeter. *M. Laurent, Paris.*

3659. Three Diaphragms and lamp stand for magic lantern.

Laurent.

3659a. Diaphragms (4), various. *Laurent, Paris.*

974. Apparatus for demonstrating the **Glory on bedewed Meadows,** consisting of glass globes filled with water.

Prof. Dr. Lommel, Erlangen.

975. Apparatus for demonstrating the **Glory on bedewed Meadows,** with solidified drops of Canada balsam.

Prof. Dr. Lommel, Erlangen.

These glass globules serve to demonstrate why dew drops shone upon by the sun appear so brilliant just round the shade of the head of the observer. The explanation is that each dew drop is a lens concentrating the rays upon the ground below the drop, which latter sends them back diffused.

If the glass globules are placed upon a sheet of white paper, and the shadow of the observer's head is permitted to fall into the circle, the globules will appear very brilliant; as soon, however, as the white reflecting sheet is removed, and the globules rest on a dark dull ground, the brilliancy at once disappears.

The preceding experiment can also be well executed with solidified drops of Canada balm.

975a. Apparatus of M. Bravais, for producing **halos, parhelia,** and other kindred phenomena. *W. G. Lettsom.*

It consists of a hollow equilateral prism made with plates of parallel glass. The prism is filled with water at an orifice on the top. It is fixed on a vertical axis rotating by clockwork. With 100 revolutions in a second it reproduces the varied series of positions of the vertical prisms of ice producing parhelia. The prism is to be illuminated by a beam of sunlight, or by a lamp at a distance of 8 or 10 yeards. The apparatus reproduces also the Anthelion; by substituting for the prism a quadrangular plate of glass turning round on one of its vertical edges. If striæ are traced on the surfaces of this plate, the anthelion becomes traversed by two symmetrical arcs, arranged in the form of a St. Andrew's cross.

See M. Bravais's *Mémoire sur les Halos*, Paris, 1847, p. 266, 4to.; or *Journal de l'École Royale Polytechnique*, XXXI. *cahier*.

976. Four Absorption Cases, all in glass, 5 and 10 mm., and two pieces for spirits and water.

Warmbrunn, Quilitz, and Co., Berlin.

977. Bunsen's Apparatus for Experiments in Spectrum Analysis, a battery of four Leyden jars, a stand with arrangements for producing a spark spectrum, with holder for spectrum tubes. *Keiser and Schmidt, Berlin.*

978a. Apparatus for measuring the magnitude of Gas Jets at a distance. Invented by Mr. C. Wolfberger.

Geneva Association for the Construction of Scientific Instruments.

This apparatus, invented by the civil engineer Wolfberger, is intended for the comparison of gas lamps from the street level.

Founded on the principle of the sextant, it is composed of two mirrors: the one fixed, the other movable parallel to the first along a graduated scale.

In order to measure the magnitude of the gas jet, the operator holding the instrument by its handle on a level with the visual ray, and looking through the sight, observes simultaneously, in a direct line, the jet to be measured, above the fixed mirror, and indirectly the image of the same jet by double reflection. The screw-head placed below the handle is then turned, until the right edge of the jet, seen in a direct line, coincides with the left edge of the jet, seen by reflection. The magnitude of the flame, ascertained, is then shown on the metallic scale which is read in millimetres.

978b. Patent Illuminating Power Meter, for showing the illuminating power of gases in the terms of the Parliamentary sperm candles and the standard quantity of five cubic feet of gas per hour by the observation of one minute. *William Sugg.*

979. Trepiscope. An optical apparatus made by the late Richard Roberts, C.E., of Manchester, and first shown at the meeting of the British Association at Dublin in 1835.
The Committee, Royal Museum, Peel Park, Salford.

On being turned by hand or by power the card on the disc is caused to revolve from 6,000 to 40,000 times a minute; on viewing the revolving disc *through the eye-hole,* the printing on the card can be read with ease and distinctness.

The time given for one view of the card may not exceed the 150,000th of a second when the disc is revolving at the highest speed.

980. Radiograph.
The Committee, Royal Museum, Peel Park, Salford.

A small apparatus to show that the spokes may be counted whilst the wheels revolve at a very high velocity. Invented by the late Richard Roberts, C.E., of Manchester.

979a. Phosphoroscope, by Becquerel..
M. J. Duboscq, Paris.

979b. Phosphorescent Tubes, set in the form of writing. These tubes preserve their brilliancy in the darkness long after being exposed to solar light. *Alvergniat Frères, Paris.*

981. Newtonian Disc, for rotating movement transmitted by caoutchouc bands. *Luizard, Paris.*

981a. Newton's Apparatus. *M. Lutz, Paris.*

983. Pair of Reflectors, for the demonstration of the laws of reflection. *Elliott Brothers.*

983a. Reflector of 22 mm. diameter, for Foucault's telescope.
M. Lutz, Paris.

983b. Apparatus illustrating Persistency of Vision.
S. F. Pichler.

983c. Magic Mirror. *Robert von Tarnow.*

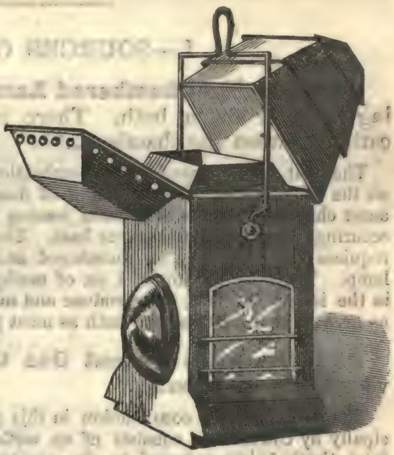
This mirror is a curiosity, and consists of a brass concave disc with finely polished surface. At the reverse rough side there are several Arabic characters in relief. By exposing the polished surface to the rays of the sun in such a way that they reflect them on the wall, the Arabic figures of the reverse side of the disc become plainly visible in the reflected light on the wall.

983c. Selenium Eye. *C. W. Siemens, F.R.S.*

994. Government Safety Magazine Lamp.
J. Gardner & Sons.

Constructed at the request of the Home Office. The aim was to invent a lamp which would burn in a powder magazine and other dangerous places in perfect safety, and would exclude the powder which, it is well known, is found floating in powder magazines and stores in the form of fine dust. After a series of experiments it was ascertained in the most conclusive manner that all safety lamps wholly or partially constructed of gauze are useless for this purpose, the gauze failing to exclude the powder dust, which, collecting inside the lamp explodes. Now the flame of a powder explosion is so much more violent than that of gas that it instantly penetrates the gauze and carries through with it incandescent particles of powder.

This patent safety magazine lamp has, therefore, been constructed on the following principle :—



To prevent risk of explosion from the entry into the lamp of the fine powder dust which may be present in a powder magazine or store, the air passages which supply this lamp, and also the exit passages for the burnt air from the flame, are constructed so that the air must pass under and over a series of screens. Air to support combustion enters the lamp under an inverted outer ledge, and then passes through holes made in the casing to a narrow space formed by an inner lining; so that the air must first pass up to reach the holes in the casing, then down the inner space, and finally up another narrow space before entering the lantern. The top part of the lamp is constructed on substantially the same principle, that is, the exit air passages are made zig-zag; but, in case they ever become clogged with soot, two out of three parts which form the passages are hinged to the casing, and are secured in place by a spring lock. When these parts are unbolted they can be turned back on their hinges and easily cleared of any soot that may have become deposited therein.

The bottom and sides of the lamp are the only parts fixed to one another, and the burner is dropped in through the top of the lamp, which is then secured with a spring lock as already mentioned.

Every detail of the outer casing of the lamp has been carefully considered, and there are no projecting parts where dust can accumulate and settle. The lamp has a bull's-eye lens in front; the side lights are glazed with glass one-eighth of an inch thick, protected by strong copper wire. The handle moves on a pivot. The burner is a $\frac{3}{4}$-inch flat wick, and a reflector is added to increase the brilliancy. The lamp and lantern are made of copper, bright tin, or tin japanned.

The highest temperature of the outer casing of the lantern has been 126° the exploding temperature of powder being 600°.

Spectacles, for shooting. *G. W. Richter.*

SECTION 8.—HEAT.

WEST GALLERY, UPPER FLOOR, ROOM Ⓠ.

I.—SOURCES OF HEAT.

984. Double-Chambered Lamp and Reservoir for heating water or air, or both. There is no blast-pipe, or communication between the chambers. *J. L. Milton.*

The heat is generated by the combustion of methylated spirit, and applied on the principle of driving a ring of flame from the holes in the top of the outer chamber against the flame issuing from the inner compartment, thus securing a great and continuous heat. The spirit in the inner chamber alone requires to be lighted. A chambered and tubed reservoir accompanies the lamp. The consumption of 1 oz. of methylated spirit in the outer, and ½ oz. in the inner chamber, will produce and maintain, for from 10 to 15 minutes, as great a heat for a vapour-bath as most persons can bear.

985. George's Patent Gas Calorigen, for warming and ventilating apartments. *John F. Farwig.*

The peculiarity of construction in this gas stove, which diffuses heat principally by convection, consists of an outlet so arranged with regard to the inlet (both being external to the apartment) that only so much air passes either way as is required to support and carry off the products of combustion.

The heat generated by combustion warms a thin coil of sheet iron in the interior of the stove, the coil being in communication at one end with the external atmosphere, and at the other with the apartment; thus a stream of fresh air, which is warmed in its passage, is drawn into, and equally diffused throughout, the apartment.

986. Bunsen Burner, improved form, with air jet to increase the temperature of the flame to any required extent without re-adjustment of height or position. *Thomas Fletcher.*

In the above, the blow-pipe flame obtained with the blast tube, when confined by the loose cap, is compact and very powerful, owing to the partial mixture of air before the blast begins to act.

987. Injector Gas Furnace, with blower, for the treatment of refractory substances at very high temperatures.

Thomas Fletcher.

This furnace will burn perfectly, in the same space, any available gas supply from 10 to 50 ft. per hour, or more, giving temperatures in exact proportion. With ½ inch gas supply, day pressure, starting with a cold furnace, silver can be melted in three minutes, cast iron in eight minutes, and cast steel in 25 minutes. With a ⅝ bore gas-pipe the furnace can be constructed to give the same results in half the time, and so on in proportion, the power being limited only by the gas supply and the fusibility of the refractory clay jacket. A small foot blower only is necessary to create a current of air in the burner tube, the jet of air from the blower acting as an injector, and drawing in the air required for combustion from the atmosphere. By closing the air slide to a greater or less extent the same burner acts equally well in proportion with any gas supply from 10 cubic feet per hour. The texture of the refractory casing is cellular throughout, and the loss of heat by radiation is practically nil.

988. Low Temperature Gas Burner, to dispense with drying closets, sand and water baths, and adapted for drying, evaporating, boiling, &c. *Thomas Fletcher.*

This burner gives a range of temperature from a gentle current of warm air without visible flame to clear red heat, and is so perfectly under control that a common glass bottle may be placed on tripod, and heated to required temperature, without risk of fracture.

For very low temperatures, the ring must be lighted through the lowest opening. This gives a steady current of heated air through the gauze above. For boiling, &c., a light must be applied on the surface of the gauze, thereby providing a large body of blue flame, which can be urged by the blast-pipe until it gives a clear red heat.

989. Hot Blast Blowpipe, for temperatures up to the fusion of platinum. *Thomas Fletcher.*

The air jet in the above is coiled round the gas pipe in a spiral form, and both are heated by three Bunsen burners underneath, which are controlled by a separate tap. By this arrangement the power is double that of the ordinary blow-pipe. When the jet is turned down to a small point of flame it will readily fuse moderately thick platinum wire.

990. Gas Crucible Furnace, for temperatures up to white heat, and requiring neither blast nor attention. *Thomas Fletcher.*

991. Gas Muffle Furnace, requiring neither blast nor attention; for temperatures up to fusing point of cast iron.

Thomas Fletcher.

992. Diagram of the Porcelain Furnace at Sèvres, part of it being open to show the interior construction. Painted by Mr. Hubertus Sattler.

Dr. Alexander Bauer, Professor, Polytechnic Institute, Vienna.

993. Diagram of the Bottom of a Blast Furnace for Smelting Iron.

Dr. Alexander Bauer, Professor, Polytechnic Institute, Vienna.

995. Gas Furnaces. Perrot System.

Geneva Association for the Construction of Scientific Instruments.

These may be set up wherever gas is laid on; the slightest draught is sufficient; and in default of a chimney in the workroom it is enough to let out the funnel through a window pane. The shape of these furnaces varies according to their intended use. There are two principal models, the melting furnace, and the muffle furnace; the latter is advantageously used for assaying copper, gold, and silver, for roasting minerals, and for melting metals for analytical purposes.

Temperatures up to 1,300 and 1,400 degrees can be obtained rapidly and with economy, and once obtained can be maintained unchanged during any length of time, and may be reduced at will.

996. Cowper's Regenerative Fire-brick Hot-blast Stoves.

E. A. Cowper.

The diagrams and model of regenerative fire-brick hot-blast stoves are illustrative of the progress of science as applied to heating the air supplied as a blast under pressure to blast furnaces for smelting iron ores and iron stone. In early times the air was always used cold, but a blast heated in cast-iron pipes was introduced by Mr. J. B. Neilson in 1829, and from that time till the year 1857 the temperature of the blast was generally only about 600° Fahrenheit, but by the application of regenerative fire-brick hot-blast stoves the temperature of the blast has been raised to 1400° and 1500° Fahrenheit, and has been accompanied by a very large saving of fuel, amounting in some cases to 7 cwt. 3 qrs. 14 lbs. of coke per ton of iron made, whilst at the same time a largely increased make of iron has been produced, varying from 20 to 30 per cent. of the original make of iron. The entire wear and tear of cast-iron pipes is avoided, as the air only passes over fire-brick surfaces previously heated by the combustion of the waste gases obtained from the top of the blast furnaces. Two stoves are used alternately, one heating blast whilst the other is being heated. Two or three stoves will heat the blast for two or three blast furnaces.

996a. Drawings of Bull's Patent Semi-continuous Brick Kilns.

Hermann Wedekind.

These kilns have been worked with great success in India and are now being introduced into this country.

They are the cheapest kilns with regard to cost of building and effect a saving of nearly two-thirds of the expenditure usually involved, and are especially suitable for temporary works.

The effective mode of feeding invented by Hofmann, has also been applied by Bull to his kiln with great success.

996b. Model of Hofmann's Circular Kiln.

Hermann Wedekind.

Hofmann's Patent Annular Ovens for the continuous burning of bricks and tiles, limes and cements, at a saving of from two-thirds to three-fourths of the fuel usually employed.

It is the joint invention of M. Fred. Hofmann, of Berlin, and M. A. Licht, of Dantzig.

It is now well known and appreciated by the trade in this country, and has been extensively employed by the Government on the extensive works at Portsmouth Dockyard, where five of the kilns have been working at a great saving to the country. About 1½ millions of bricks are daily burnt in them in England alone. Taking coal at an average price of 10s. per ton, this invention will give a saving of at least 60,000*l.* per annum. In burning lime equally favourable results have been realised as in burning bricks.

997. Gas Lamp, consisting of four Bunsen burners, and provided with an air-regulating system.
S. Hoogewerff, Dr. Phil., Rotterdam.

This lamp, which is intended for heating tubes, was constructed by Mr. Verkerck, mechanical engineer, Utrecht, under the directions of Dr. Hoogewerff, and belongs to the middle school at Rotterdam.

998. Gas Lamp (Bunsen's system), intended for heating porcelain vessels of large size.
S. Hoogewerff, Dr. Phil., Rotterdam.

It was constructed, under the directions of Dr. Hoogewerff, by Mr. Verkerck, mechanical engineer, Utrecht, and belongs to the middle school at Rotterdam.

999. Apparatus for showing **the liberation of heat** during solidification. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

II.—EXPANSION.

1088a. Apparatus, by **Peter von Musschenbroek,** a Dutch mathematician (born 1692, died 1761), to determine the relative values of the **Coefficients** of the **Expansion** of **Solid Bodies.** *Prof. Dr. P. J. Rijke, Leyden.*

1097b. Original Apparatus, by **M. Dulong** and **Petit,** for measuring the **Dilatation** of **Mercury** with overflow thermometer. *Polytechnic School, Paris.*

1097c. Apparatus for measuring the expansion of Bodies by Heat. *Physical Institute, Freiburg.*

1097d. Apparatus to demonstrate the mechanical effects of the expansion of Fluids by Heat.
Prof. Boscha, Royal Polytechnic School, Delft.

1090b. Original Apparatus of **Regnault** for the **Dilatation of Gases.** *College of France, Paris.*

1075. Apparatus for demonstrating the **Expansion of Solids by Heat.** *A. Steger, Kiel.*

1090. M. Fizeau's Apparatus for measuring the **Coefficient** of **Dilatation.**
Conservatoire des Arts et Métiers, Paris.

1082a. Photograph of M. Fizeau's Apparatus for determining the **Coefficients** of **Dilatation.**
M. Laurent, Paris.

1082b. Microgoniometer. An instrument for measuring the expansion of metals by heat. *Prof. Dr. F. Pfaff.*

1087. Model of Circular red hot Copper Railway, for causing a metal ball to rotate by means of unequal expansion by heat. *George Gore, F.R.S.*

Model in wood of circular railway, which when formed of copper heated to redness, and a thin cold ball of German-silver placed upon it, the ball rotates by the influence of unequal expansion produced by the heat. (*See* Philosophical Magazine, August 1859.)

III.—THERMOMETRY AND PYROMETRY.

Air Thermometer, in the form first given by **Galileo.**
The Royal Institute of "Studii Superiori," Florence.

Padre Benedetto Castelli, one of Galileo's disciples, writes about the thermometer as follows :—"I recollect an experiment shown me, about the year " 1603, by our Sig. Galileo. He took a glass bottle of about the size of an " egg, having a neck nearly two palmi in length and as thin as a wheat " straw, and having warmed it well with his hands, he then turned its mouth " upside down into a vessel placed underneath in which there was a little " water. When he had removed his hands from the bottle the water began " immediately to rise in the neck, and mounted higher, by more than a palmo, " than the level of the water in the vessel. Sig. Galileo made use of this " effect to construct an instrument for examining the degrees of heat and of " cold, concerning which much might be said."

And then Vincenzo Viviani, another disciple of Galileo's, in the life of that great man, which he wrote between 1593 and 1597, states that Galileo invented the thermometer.

1828. Registering Thermometer of Fontani.
The Royal Institute of "Studii Superiori," Florence.

Thermometer, cinquantigrade, with spherical bulb. The freezing point corresponds to 13°·5. The academicians used this thermometer for the meteorological observations instituted first by them in 1654. *Accademia del Cimento.*

Thermometer, cinquantigrade, with cylindric bulb. The point of ice melting corresponds to 13°·5.
Accademia del Cimento.

Thermometer, settantigrade. The freezing point is at 23°·5.
Accademia del Cimento.

Thermometer for bath. When immersed in the bath it must indicate 49°, as is written in the upper little ball.
Accademia del Cimento.

Thermometer, with foot divided in 470°, corresponding to 26° centig. It served for the experiment made to ascertain whether the cold of ice reflects itself from the mirror like the heat of burning coals and light. *Accademia del Cimento.*

Thermometer, with elaborate foot. An object of art.
Accademia del Cimento.

Thermometer in winding form, very sensitive, height 32 cm.; the spiral tube is 2·30 meters long. *Accademia del Cimento.*

Thermometer, with balls (thermoscope). The alcohol dilating by heat, the little balls fall one after another according to their weight. *Accademia del Cimento.*

The Accademia del Cimento was founded by Prince Leopoldo de' Medici, brother of the Grand Duke Ferdinand II., who also greatly favoured it. The first assembly was held at the Palazzo Pitti in Florence on the 18th of June 1657; and it chose for a device the celebrated motto "Provando e Riprovando." After ten years of existence, Prince Leopold having been made a Cardinal, the academy was dissolved.

1075a. 'sGravesande's Ball and Ring Pyrometer, for showing expansion. *Harvey, Reynolds, and Co.*

1076. Musschenbroek's Pyrometer made in the first half of the 18th century, with five different metal bars, and an autograph. Property of His Highness Prince Pless, Schloss Fürstenstein. *The Breslau Committee.*

The apparatus has been constructed after the description and drawing given on p. 12 and Table XXX. of Musschenbroek's "Tentamina Experimen-"torum Naturalium Captorum in Academia del Cimento, Lugduni, 1731, "Pars. II." The orthography of the French, on an annexed slip of paper, is that of the beginning of the last century. The instrument, which is in capital condition, may therefore be considered as one of the oldest of its kind.

1027. Original Spirit Thermometer, of the Florentine Accademia del Cimento (17th century). *The Royal Institution of Great Britain.*

Presented to the Royal Institution by Sir Henry Holland, Bart., F.R.S.

1003. Photographs of Old Thermometers; a small alcohol thermometer, with Florentine scale, and four larger ones by Michelo du Crest (1754). *Prof. Hagenbach-Bischoff, Director, The Physical Institute in the Bernoullianum, Basle.*

In these alcohol thermometers zero indicates the temperature of the cellar under the Observatory of Paris, and 100° the boiling point of water.

1070. Wedgwood's Pyrometer, invented in 1782. *Edinburgh Museum of Science and Art.*

Dry clay when exposed to high temperatures contracts uniformly, and Wedgwood believed that by the amount of contraction the temperature which produced it could be measured. The instrument, however, is not trustworthy. This specimen was made by Josiah Wedgwood, and presented to the Edinburgh Museum by his grandson Mr. Godfrey Wedgwood.

1067. Wedgwood's Pyrometer, consisting of pieces of clay, contracting according to the heat to which they are exposed. These are afterwards slid along the gradually diminishing and graduated groove in the brass plate, and so indicate the degree of heat to which they have been exposed. *Robert Garner, F.R.C.S.*

1078. Early Pyrometer (by Funiey).
The Council of King's College, London.

1079. Daniell's Pyrometer, employed in researches by Professor Daniell. *The Council of King's College, London.*

1052a. Original Air Thermometer, by M. Regnault.
College of France.

1000. Thermometer. "The Great Pyramid temperature scale, and its standard reference point of 50° P." With a map of the world to illustrate the advantages of this standard.
Prof. Piazzi Smyth.

This consists of a large table thermometer, graduated according to the indications of the Great Pyramid system of standards; firstly, by colours into fifths of the distance between freezing and boiling of water, and then each fifth into 50, or 250 for the whole distance.

A map of the world on an equal-surface projection accompanies the thermometer, and exhibits the mean temperature of the whole earth's surface according to the Great Pyramid scale; illustrating also the territorial and international advantages to all civilised nations of adopting the mean temperature standard of the Great Pyramid, viz., 50° Pyr. or 68° Fahr., as the temperature reference standard for all human purposes, scientific, social, and commercial.

1001. Legible Spirit Thermometers, with line at above and below the proper temperature of a room, so that the degree can be read off at a long distance, at the opposite side of a large room, or at the ceiling, for experiments in ventilation.
Peter Hinckes Bird, F.R.C.S. Lond.

1002. Apparatus for determining the **Boiling Point of a small quantity of Fluid.**
The Secondary Government School, Assen (Netherlands).

In this simple apparatus, constructed after the design of Dr. A. Van Hasselt, (teacher at the school for middle-class education at Assen), the small tube is filled for the greater part with mercury; the remaining space with the fluid. The tube is then turned upside down into a small beaker-jar, which is also filled with mercury; part of this must be removed until the quantity left rises about one or two centimetres above the bottom of the jar. When the apparatus has been placed in the large beaker-jar, water or oil is poured into the latter, so that the tube is quite immersed. The jar is then heated, agitating the fluid meanwhile with a moving apparatus.

The millimetre scale serves to determine the height of the fluid in the larger jar, together with the difference between the position of the mercury in the tube and that on the outside of it. In determining this difference, the pressure of the fluid in the larger beaker-jar and the barometric height must be taken into consideration.

To know whether a fluid is homogeneous, two experiments must be made, one with a fluid which is partially evaporated. In both cases the results must be the same.

When the vapour of the fluid in the tube has the pressure of one atmosphere the boiling point of the fluid must be observed.

1375a. Air Thermometer after Riess.

Warmbrunn, Quilitz, & Co., Berlin.

1004. Trough for comparing Thermometers, provided with in- and out-flow tubes for water, and stirring apparatus.

Dr. J. W. Gunning, Professor of Chemistry at the "Athenæum illustre," Amsterdam.

The thermometers are placed in a movable frame, in which they may be transported from one trough into another containing water of another temperature. Two sheets of glass, placed on either side of the frame, prevent the inner portion of the water from cooling.

1005. Dial Thermometer, designed by L. R. Brühne, Leyden.

Dr. D. de Loos, Director of the Secondary Town School, Leyden.

This thermometer is intended to admit of a large number of students seeing, from a distance, the change in the volume of the mercury as the temperature varies.

In the mercury is a small glass tube, balanced by another similar tube, both being joined together by a thread, which is suspended over a small copper box, at the extremity of which is a needle moving over a dial.

1006. Mercurial Dial Thermometer, adapted for class experiments on specific and latent heat.

Prof. W. F. Barrett.

The expansion of the mercury in the bulb of the thermometer lifts a small iron piston which communicates its motion to the index hand. Small variations of temperature are thus readily seen by a large class, *e.g.*, the expansion of the glass of the bulb causing a momentary retreat of the index hand, is seen to be the first effect produced by heat on the bulb. By making the scale on glass the dial can be projected on a screen and determination of specific and latent heat made before a large class; electric contact can also be made by the hands, and thus a self-registering thermometer constructed. The instrument was made by Mr. Yeates, of Dublin.

1011. Various Thermometers, of different kinds, in metal, ivory, porcelain, glass, and wood. *Elliott Brothers.*

1012. Standard Thermometer. *Elliott Brothers.*

1013. Insolation Thermometer, for determining the intensity of the rays of the sun (maximum thermometer), with holder.

Ch. F. Geissler & Son, Berlin.

1014. Eight Normal Thermometers, executed by Greiner and Geissler, Berlin.

Imperial Admiralty Hydrographical Bureau at Berlin, and Deutsche Seewarte, Hamburg.

These thermometers are employed in the stations of the Naval Observatory and in the Imperial Navy.

1015a. Thermometer, with corrected Freezing Point.
W. Gloukhoff, St. Petersburg.

This thermometer is constructed on a principle much used in Germany. To it is added only a contrivance to render the scale more steady, and to correct the error of *freezing point,* by raising or lowering of the scale. By unscrewing the upper metallic cap of the thermometer, this contrivance becomes visible.

1016. Reaumur's Scale. *Dring and Fage.*

Formerly much used in Germany and Russia, now mostly in Norway and Sweden, and some parts of Denmark. The zero of this scale is at the melting point of ice. The interval between this and boiling point is divided into 80 degrees.

1017. De Lisle's Scale. *Dring and Fage.*

This scale is seldom used; zero is fixed at boiling point; the interval between this and freezing point is divided into 150 degrees.

1018. Six's Thermometer on a porcelain scale (named after its inventor, Mr. Six of Canterbury) for registering extremes of temperature. *Dring and Fage.*

The indices are little pieces of steel coated with glass which are enabled to retain their position in the tube by means of a hair fastened round them, and by this means the highest or lowest temperature is recorded.

1018a. Six's Thermometer with a very flat bulb which renders it as sensitive as an ordinary mercurial thermometer. *S. G. Denton.*

1018b. Six's Thermometer with mercurial wet bulb thermometer attached, thereby combining four instruments in one, namely, maximum, minimum, hygrometer, and present temperature. *S. G. Denton.*

1019. Long Brass-Cased Thermometer. Showing the difference in length of the mercurial column after being pointed and divided with the whole length of the tube immersed in water at the various temperatures between 32° and 212°; the same with the bulb only in the water. *Dring and Fage.*

1020. Very delicate Spiral Bulb Thermometer. Extremely sensitive, capable of indicating small variations of temperature. *Dring and Fage.*

1022. Standard Thermometer, calibrated throughout. *Dring and Fage.*

A standard thermometer divided on the tube, used for purposes where great accuracy is required. The tubes used for these thermometers are selected with great care, particular attention being paid to the uniformity of the bore. The method of ascertaining this is usually performed as follows:—A portion of mercury is introduced into the tube, and the length it occupies is noted; it is then carried a little further on, and its length compared with the former length. So on all down the tube; if the length has decreased from the first measurement, it shows that the bore of the tube has increased, and vice versâ. The process is known as calibration.

1023. Four Thermometers. Showing the different scales principally in use. Fahrenheit, Celsius or Centigrade, Reaumur, and De Lisle. *Dring and Fage.*

Fahrenheit's scale is used principally in Great Britain, its Colonies, and the United States. The zero of this scale is obtained from a mixture of salt and snow; thirty-two degrees is the point at which ice begins to melt, and 212, or boiling point, from boiling water, when the barometer stands at 29·905. One advantage of this scale is that temperatures may often be expressed in whole degrees, whereas in other scales fractions of degrees are frequently necessary.

1024. Celsius or Centigrade Scale. Generally used on the continent. *Dring and Fage.*

The zero of this scale is that point at which ice begins to melt, and 100 the point at which water boils when the barometer stands at 760mm. Celsius is the name of the inventor of this scale; it is called Centigrade from its being divided centesimally.

1025. Becquerel's Thermo-Electric Thermometer.
Conservatoire des Arts et Métiers, Paris.

1025a. Becquerel's Thermo-Electric Pyrometer.
Conservatoire des Arts et Métiers.

1026. Hodgkinson's Actinometer. Described in the Proceedings of the Royal Society, vol. XX., p. 328.
Kew Committee of the Royal Society.

This is a large thermometer, filled with alcohol coloured blue, and having a bore much contracted for a great part of its length, in order that the scale may be very open; at its top it opens out into a large chamber, which receives the superfluous fluid at the time of observation.

A tin case, capped with glass at both ends, prevents the access of extraneous rays to the bulb of the instrument at the time of observation.

1028. Drawings, various, partly new, of constructions of Differential Atmospheric Thermometers.
Dr. Leopold Pfaundler, Professor of Physics, Innsbruck.

This plate presents a general view of all possible forms of construction, which partly appear as modifications of Berthelot's atmospheric thermometers, partly are based on independent principles.

For further details, see Transactions of the Imperial Academy of Sciences at Vienna, Vol. LXXII., 1875.

1029. Melloni's Thermo-Electric Apparatus.
M. Ruhmkorff.

1029a. Line Pile for Spectrum and Galvanometer.
M. Ruhmkorff.

1286. Nobili's Thermo-Electric Pile, of 54 pairs of bismuth and antimony bars, soldered alternately together; the smallest temperature between the two faces of the pile develops a current, readily indicated by a suitable galvanometer. *Elliott Brothers.*

1033. Thermometer Electric Alarum, for giving notice when a given temperature is reached. *Dr. Letts.*

The apparatus consists of an open thermometer with large bulb and wide tube. A platinum wire is sealed into the bulb, and another wire passes down the tube. The latter can be so adjusted that at a given temperature its end is touched by the mercury in the tube. The two wires being connected with an electric bell and battery, as soon as the mercury touches the wire, contact is made and the bell rings.

The apparatus was used in experiments with the glass digester, and served to give notice at some distance from the room in which the latter was being heated when the desired temperature had been reached, thus rendering an actual observation of the temperature unnecessary, and so preventing all danger in case of an explosion.

1034. Normal Thermometer, divided in tenths of a degree from 0° to 105° C.
Will. Haak, Neuhaus am Rennweg, Thüringen.

1035. Normal Thermometer, in a narrow glass cylinder with a small mercury bulb; divided in tenths of a degree from 0° to 105° C. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1036. Normal Thermometer, divided to tenths from −35° to +50° C. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1038. Two Thermometers, for chemical work, from −10° to +360°. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1039. Two Thermometers, from 100° to 360°.
Will. Haak, Neuhaus am Rennweg, Thüringen.

1040. Two Thermometers, from 0° to 150°.
Will. Haak, Neuhaus am Rennweg, Thüringen.

1041. Two Thermometers, with divisions etched on the tube. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1045. Various Pressure Thermometers, on the plan of Mitscherlich. *See* accompanying pamphlet.
Prof. Mitscherlich, Münden.

1046. Metallic Thermometer for Lectures, on the plan of W. Beetz, constructed by Sauerwald, of Berlin. Consult the adjoining description and scheme. *Prof. Beetz, Münich.*

1047. Model of an **Apparatus for measuring Temperatures by means of Thermo-batteries.**
Dr. J. Pernet, Breslau.

The apparatus permits the quick and trustworthy determination of the temperature of the several soldered places, as well as the differences of temperature of any two soldered places.

In the first case the resistances of the single conductors (except the resistances of the two soldered places, which are exposed to constant temperatures, and show always the same resistance) may be different. In the other case the resistances of all soldered places must be capable to be made equal.

1048. Diagrams, illustrating the application of the **Apparatus for the Measurement of the Temperature of the Earth** and of metal tools. *Dr. J. Pernet, Breslau.*

1049. Normal Thermometer, divided in tenths of a degree from −5° to +105° C. *Ch. F. Geissler and Son, Berlin.*

1050. Chemical Thermometer from −10° to +360° C. *Ch. F. Geissler and Son, Berlin.*

2582. Collection of **Thermometers.** *Dr. H. Geissler, Bonn.*

1050a. Thermometer for Cooking, range to 600° F. *Harvey, Reynolds, and Co.*

See Mrs. Buckton's book "Health in the House," page 153.

1051. Apparatus for determining the **Temperature of Fusion.** (Compare the adjoined description.) *Prof. Dr. Himly, Kiel.*

1052. Air Thermometer on the plan of Jolly. Compare Poggendorff's Annalen, Jubelband, 1873. *University of Munich (Prof. v. Jolly).*

1053. Thermopile on the plan of Melloni of 64 bismuth antimony elements. *Wesselhöft, Halle.*

1054. Thermometer Stick for measuring temperatures at some depth. *Ludwig Meyer, Berlin.*

The instrument, adapted for depths down to 3 feet, is chiefly distinguished by the strength of its construction.

The bulb is in the nickel clamp, which latter stands by means of mercury in thermal connexion with the bulb. This mercury serves also as buffer to the thermometer bulb.

The horn clamp is replaceable by an iron screw, which facilitates the introduction of the thermometer into the ground.

Care is taken that only the clamp be thermo-conducting, not the whole tube.

1055. Milligrade Thermometer. The milligrade scale is one in which the interval of temperature between the freezing and boiling points of mercury is divided into one thousand degrees. *John Williams, F.C.S.*

According to Dulong and Petit, mercury freezes at −39·44° C., and boils at +360° C. For convenience, assuming that the freezing point is −40° C., the interval is therefore 400 degrees C., thus it follows that $2\frac{1}{2}$ degrees milligrade are equal to 1 degree centigrade. Upon this scale the following results are obtained. Water freezes at 100° M. and boils at 350° M., the interval 250° being just one-fourth of the interval between the freezing and boiling points of mercury. Many other substances also show a curious relation in the interval between their freezing and boiling points to that of mercury, facts which are not obvious upon other thermometric scales.

The practical advantages of this system of graduation consist in the comparative smallness of the degrees, thus avoiding in many cases the necessity of the use of fractions to express the boiling point of substances; also that the zero point being so low the scale is a continuous one, all numbers under 100° M. representing temperatures below freezing water, but avoiding the necessity of the use of the minus sign, and at higher temperatures as 1,000° is approached, giving a clear idea that the heat is arriving at the extreme limit of thermometric registration.

In practically graduating this thermometer reference is not made to the freezing or boiling points of mercury, but the freezing point of water is marked as 100°, and the boiling point as 350°, and the scale carried upwards or downwards as required.

The conversion of centigrade degrees into milligrade degrees, or *vice versâ*, is extremely simple. A centigrade degree multiplied by 2½, and 100 added, gives the milligrade degree, thus 40° C. multiplied by 2½ is 100, and 100 added gives 200, the degree on the milligrade scale. The correspondence between the Fahrenheit and the milligrade graduation is not so simple, as the interval on the Fahrenheit scale between the freezing and boiling points of water being 180° F., higher numbers are required to be used in the calculation. The following are the lowest common numbers for the scales:—25° milligrade, equal to 10° cent. and equal to 18° Fahr.

Thus it follows that the following rules can be applied to calculate one scale with the others—

To convert centigrade into milligrade degrees -	$n \times 5 \div 2 + 100$.
To convert milligrade into centigrade degrees -	$n - 100 \times 2 \div 5$.
To convert Fahrenheit into milligrade degrees -	$n + 40 \times 25 \div 18$.
To convert milligrade into Fahrenheit degrees -	$n \times 18 \div 25 - 40$.

1055a. Thermometer, with 19 differently graduated scales, traced on a silvered metal plate; the centre is occupied by the thermometer-tube and bulb. This instrument was made in 1754.

Prof. Buys-Ballot, Utrecht.

1055b. Four Registering Thermometers.

E. Cetti and Co.

1055c. Siemens' Pyrometer. *E. Cetti and Co.*

1055d. Metallic Thermometer, indicating two temperatures. *Francis Pizzorno, Bologna, Italy.*

The movements of the index are in this instrument produced by the dilatation of two zinc blades which in the figure are seen edgewise. Along the graduated arc can be fixed two sliding pieces; if the index touches one of them, it closes an electric circuit and rings a bell. Two small pearls carried by a thread stretched between the extremities of the graduated arc, and which are displaced by the index in its movements, serve to indicate the maximum and minimum temperature.

1055e. Five Thermometers, various. *E. Cetti and Co.*

1055f. Mathiessen's Differential Thermometer.

E. Cetti and Co.

1068. Pyrometer, of iron and copper, for lecture illustration. *Yeates and Sons.*

The above consists of a compound bar of iron and copper, bent into the form of U, one arm of which is firmly attached to the stand; the other arm is free, and carries a long index. If the compound U be immersed in a beaker of boiling water, the index will move over several degrees of the scale.

1069. Reflecting Pyrometer, for showing by projection the difference of expansion of different metals. *Yeates and Sons.*

1074. Pyrometer. *O. Schütte, Cologne.*

The pyrometer for determining the temperature of the heated blast-current deserves particular attention on the part of proprietors, overseers, &c. of foundries, on account of the simplicity of its construction, which is proof against deranging influences, although constantly exposed to a destructive element, viz., the glowing hot current, the more especially as no pyrometer has been made as yet with which temperatures up to 600 degrees Celsius and more can be continuously determined.

By the application of this pyrometer it will be possible to control at any time the apparatus and the stokers, and in cases where Siemens' or other similar apparatus are employed, to determine the exact time when the same must be reversed. The pyrometer, likewise, indicates any disturbing influences occurring in the flues, variations in the fuel, in the atmosphere, &c., and thus offers the best guarantee that the heating of the apparatus is not forced to such an extremity as to cause the destruction of the pipes, stop-valve, &c.

1071. Copper Pyrometer, for determining the temperature of blast when highly heated. *E. A. Cowper.*

The temperature of the blast is readily ascertained by heating a small piece of copper in it, and then dropping the copper into a pint of water in a copper vessel surrounded by a non-conductor, and where a thermometer shows one degree for every fifty degrees the copper had been heated. The thermometer is provided with two scales, one fixed, showing the temperature of the water, the other sliding, showing the temperature of the blast.

1074a. Water Pyrometer. *C. W. Siemens.*

The pyrometer consists of a copper vessel, capable of holding rather more than a pint of water, and well protected against radiation by having its sides and bottom composed of a double casing, the inner compartment of which is filled with felt. A good mercury thermometer is fixed in it, having, in addition to the ordinary scale, a small sliding scale, graduated and figured with 50 degrees to 1 degree of the thermometer scale; there are also some cylindrical pieces of copper provided with the pyrometer, each accurately adjusted in size, so that its total capacity for absorbing heat shall be 1–50th that of a pint of water.

In using the pyrometer, a pint (0·568 litre, or 34·66 cubic inches) of water is measured into the copper vessel, and the sliding pyrometer scale is set with its zero at the temperature of the water as indicated by the mercury thermometer; a copper cylinder is then put into the furnace or hot blast current the temperature of which it is wished to ascertain, and is allowed to become heated for a time varying from 2 to 10 minutes, according to the intensity of the heat to be measured.

It is then to be withdrawn and quickly dropped into the water in the copper vessel, where it raises the temperature of the water in the proportion of 1 degree for each 50 degrees of the temperature of the copper. The rise of the temperature may then be read off at once on the pyrometer scale, and, if to this is added the temperature of the water as indicated on the mercury thermometer before the experiment, the exact temperature required is obtained.

For very high temperatures platinum cylinders may be employed instead of copper.

1074b. Electrical Pyrometer. *C. W. Siemens.*

The electrical resistance of metal conductors depends upon their dimensions, material, and temperature; an increase of the latter causing a corresponding increase of resistance. The law of this increase is known.

Thus, the resistance of a conductor being ascertained at zero centigrade, it can be calculated for any temperature, and *vice versâ;* if the resistance can be found by measurement, the temperature can be calculated. This is the principle upon which Siemens' electrical pyrometer is based.

A platinum coil of a known resistance at zero centigrade is coiled on a cylinder of fire-clay, protected by a platinum shield, which is placed in an iron or platinum tube, and then exposed to the temperature to be determined. Leading wires are arranged to connect this coil with an instrument suitable for measuring its resistance, and from this resistance the temperature can be calculated.

The instrument supplied for this purpose is a differential voltameter.

The differential voltameter consists of two separate glass tubes, in each of which a mixture of sulphuric acid and water is decomposed by an electrical current passing between two platinum electrodes. The gas which is generated is collected in the long cylindrical and carefully-calibrated top of the tube, and its quantity is read off by means of a graduated scale fixed behind the tubes.

Movable reservoirs are provided communicating with the tubes to regulate the level of the liquid.

The current of the battery is divided (by passing a commutator) into two circuits, one of which consists of standard resistance in the instrument and the platinum electrodes in one tube; the other, of the resistance to be measured and the electrodes in the other tube. The quantities of gas developed in the two tubes are in inverse proportion to the resistances of their respective circuits, therefore one of the resistances, viz., that in the instrument, being known, the other can be calculated.

Directions for use:—Fill the battery glasses with pure water, or, in case of the power of the battery decreasing, with a solution of sal-ammoniac in water. Connect the poles to B and B′ on the commutator. Expose the small end of the pyrometer-tube, as far as the cone, to the heat to be measured, and connect the terminals x, x', c to the ends of the leading cable bearing corresponding letters. Connect the other end of the leading cable to the terminals x, x', c on the voltameter.

The differential voltameter is to be filled with the diluted sulphuric acid through the reservoirs, the india-rubber cushions being lifted from the top of the tubes. The commutator is to be turned so that the contact springs on both sides rest on the ebonite. The liquid in both tubes is to be regulated to the same level (zero of scale), and the india-rubber cushions to be let down again. Give the commutator a quarter of a turn, and the development of gas will commence almost immediately. Turn the commutator half round every ten seconds to reverse the current. Keep the current passing until the liquid has fallen in the tubes to at least 50 degrees of the scale, then put the commutator in its first position, so that the contact springs rest on the ebonite; read off the level of the liquids on the scale marked V, and the scale marked $\dot{V}$; find these numbers in the table under V and $\dot{V}$, and the intersecting point of the lines starting from these figures gives the temperature.

For a new experiment adjust the levels as before.

1077. Bailey's Patent Civil Engineers' Pyrometer, for ascertaining the temperature of flues, &c., with sheath and boxwood handle to enable managers of works and others to carry it about with them for use when necessary. *W. H. Bailey & Co.*

1080. Bailey's Patent Flue Pyrometer, for testing the temperature of boiler flues, hot-air chambers, stoves, galvanisers, &c. *W. H. Bailey & Co.*

1080a. Hobson's Patent Hot Blast Pyrometer.
Joseph Casartelli.

In this instrument the aim is to tone down the temperature of the blast by an admixture of a constant proportion of cold atmospheric air, so that the highest temperature likely to have to be recorded is brought within the range of a good mercurial thermometer. The hot blast is introduced in the form of a jet, which by suitable arrangement is made to induce a stream of atmospheric air; the mixed stream then passes on, and impinges on the bulb of the thermometer. The scale has been laid down by experiment, and the instrument gives the same reading as Siemens' copper ball pyrometer. It is found that pressure does not affect the result; and, as all the instruments are made exactly alike, the same result is invariably obtained. By the use of this instrument much time is saved, and the result is more trustworthy than with any other instrument in use.

1080b. Casartelli's Improved Pyrometer, for ascertaining the temperature of flues, stoves, &c. *Joseph Casartelli.*

This instrument consists of two different metals of different ratios of expansion, and any permanent set which may take place in the metals is compensated by the fact that the set will take place in opposite directions. The scale is laid down by experiment. It is so constructed that it is only necessary to expose one half of the stem to the action of the heat.

1081. Bailey's Patent Bakers' Pyrometer, "Bakers' Guide," for ascertaining the temperature of bakers' ovens, and enabling them to prevent the possibility of the bread becoming burnt, by keeping the oven at one uniform temperature.
W. H. Bailey & Co.

1082. Wood and Bailey's Patent Blast Furnace Pyrometer, for ascertaining the temperature of hot blasts.
W. H. Bailey & Co.

IV.—CALORIMETRY.

1063a. Original Apparatus of **M. Regnault** for ascertaining **Specific Heat** by observing **Refrigeration.**
College of France, Paris.

1097a. Diagrams (3), representing the **Apparatus** of **M. Regnault,** by M. d'Obelliane. *Polytechnic School, Paris.*

1064. Lavoisier's original Calorimeter.
Conservatoire des Arts et Métiers, Paris.

Fabre and Silbermann's original Calorimeter, for measuring the heat disengaged in combustion.
Conservatoire des Arts et Métiers, Paris.

1064a. Original Vessel, by **Dulong,** for measuring **Specific Heat** by **Refrigeration.** *Polytechnic School, Paris.*

1064b. Original Apparatus, by **M. Regnault,** for ascertaining the **latent Heat** of **Steam** at different pressures.
College of France, Paris.

1057. Apparatus employed by Dr. Andrews in his experiments on the amount of heat disengaged in the combination of hydrogen and other combustible gases with oxygen. *Dr. Andrews, F.R.S.*

The gases contained in a cylindrical vessel of thin copper are exploded by the ignition of a fine platinum wire, and the heat is measured by the rise of temperature of the water in a calorimeter, capable of being rotated gently round its horizontal axis.

1058. Apparatus for determining the amount of heat produced in the combination of liquids and solids with oxygen.
Dr. Andrews, F.R.S.

1058a. Fabre and Silbermann's Calorimeter.
L. Golaz, Paris.

This apparatus consists of :—1. A large brass vessel closed by a cover in two parts and open in the centre. 2. A thin copper vessel coated with silver in the interior. 3. A vessel like the preceding, fitted with a cover. The calorimeter is supported in the centre of the second enclosure. The space between it and the second enclosure being lined with the skin of a swan. In the interior of this vessel is placed an agitator and a thermometer, made with great precision. All these different enclosures are placed in a large and solid triangular support, having two plates united by three copper columns.

The combustion chamber is a thin copper vessel, having at its upper extremity an opening closed by a plug flush with the side of the chamber, and provided with a tube by which the gases and the products of the combustion are discharged. A helix formed by a thin tube is fixed to this opening, and so arranged that the gases pass through it from end to end, and are discharged at the upper extremity, whence they are collected in vessels placed for that purpose. A second tube is fixed to the combustion chamber reaching to the lower part, and serves for introducing the oxygen into the chamber. The stopper is formed of a piece of metal exactly fitting the upper part of the combustion chamber, and carrying two tubes, by one of which can be introduced the pipes for hydrogen or oxygen according to the nature of the combustion desired. The other is used for watching the combustion. For that purpose it is closed at its lower end by a threefold plate, of glass, quartz, and alum; a small looking-glass is placed at the upper end of this tube, and by this means all that is going on in the interior can be seen.

1058b. Regnault's Apparatus for determining Specific Heat of Gas. *L. Golaz, Paris.*

This apparatus, constructed for M. Regnault by the exhibitor, consists of three parts:—

1. This affords the means of obtaining a current of gas, the velocity of which is constant and can be regulated as desired.
2. The bath, which imparts a determinate initial temperature to the gas.
3. The calorimeter in which the gas parts with its excess of heat.

The first part of the apparatus is composed of a copper reservoir, holding about 35 litres, and provided with two stop-cocks. It is placed in a vessel filled with water, which keeps it at a temperature sensibly constant, and always accurately known. The central reservoir is full of gas under a pressure determined by a syphon pressure gauge.

The flow of the gas is regulated by a delicate valve formed of a vertical tube, in which a close fitting spindle works by means of a micrometer screw. The end of the spindle is conical, and fits into a corresponding seating at the bottom of the tube. The diameter of the spindle is slightly diminished about one centimeter above the cone. The gas passes into the valve through a capillary opening at the apex of the conical seating, and passes out round the diminished part of the spindle to the outlet pipe, which is about a centimeter above the inlet. In connexion with the outlet pipe is a syphon pressure gauge. The amount of clearance given to the valve is indicated by a graduated disc fitted to the top of the spindle.

The oil-bath which heats the current of gas consists of a cylindrical vessel, in which is a helical tube ten metres in length. Its extremity is connected with the calorimeter by means of a nozzle, in which is fitted a small tapering glass tube by means of a cork, through which it passes. The bath has a cover at the top, through the middle of which passes a square rod carrying an agitator; a short tube fixed to the cover, near the exit of the gas, allows of the introduction of a thermometer, so that the temperature of the gas before entering the calorimeter can be ascertained.

The boiler is preserved from immediate contact with the surrounding air by means of a metallic jacket, which serves at the same time as a support; the base of this support is furnished with levelling screws; an iron column placed behind supports a rod with a clamp holding a horizontal bar, at the end of which is a pulley over which passes the cord sustaining the agitator. The bath is warmed by a gas lamp.

On leaving the bath, the gas goes into the calorimeter, which consists of a cylindrical vessel of thin brass, provided with a nozzle through which the gas enters, and 4 shallow cylindrical boxes, through all of which the gas passes successively. These boxes communicate with one another and with the lower vessel by means of tubes suitably arranged; on leaving the uppermost box, the gas discharges itself into the atmosphere by a short tube. A very thin strip of brass bent spirally is in the interior of each box; so that the gas on leaving the principal vessel traverses successively the superposed boxes, circulating the while for a long time in contact with their cold sides and in the ducts which offer sections sufficiently large for resistance to be but very feeble. All these boxes are contained in a cylindrical vessel made of brass, into which a determined volume of water, at a known temperature, is poured. In this first envelope is a thermometer and an agitator. To preserve the calorimeter from irregular currents of air it is enclosed in a second vessel, the bottom of which is provided with three small cones made of wood or cork, on which is placed the calorimeter. This vessel has a hole in the side to allow the tube of the calorimeter to pass through, and a cover in which are two holes, one of which affords a passage for the discharge tube, and the other for the stem of the agitator. It has, moreover, a third opening through which the thermometer is introduced. Finally the calorimeter and its envelopes are supported and fixed at their proper height by means of an adjustable foot.

The details of the experiments made, and the latest information published by M. Regnault, will be found in the "Mémoires de l'Academie des Sciences," vol. 26, p. 41.

1058bb. Regnault's Apparatus for determining the Specific Heat of Solids. *L. Golaz, Paris.*

This apparatus, made by the exhibitor for M. Regnault on a new pattern, enables experiments to be made with great ease and rapidity. It is composed of three distinct parts:—1. The stove for heating the body which is to be investigated. 2. The apparatus for the production of steam. 3. The calorimeter.

1. This consists of three concentric tubes closed at their upper ends by a copper plate attached by bolts to the circumference of the outside tube, at the centre there is an opening of the size of the central tube and closed by a metallic plug with double sides, in the centre of which there is another opening in which a thermometer is fixed. At the lower end of the tubes there is bolted a metallic plate similar to the one above, and terminating in a cone; the central tube also has an outlet at the base of this piece, the second enclosure descends near the sides of the cone, the third enclosure is attached to this piece. The vapour issuing from an apparatus to be described further on reaches the lower part or base of the cone, between the first and second enclosure, circulates all round and warms the centre, leaves this chamber by holes made at the top of this tube and passes once more into the third enclosure, whence it goes into the neighbouring condenser.

2. The apparatus for producing the steam is a copper boiler furnished with three tubes, the first of which, placed in the centre, receives an apparatus of copper in which the steam on its way back is condensed; above the condenser is a funnel fed by a current of water which accelerates condensation; a return tube reaches to the bottom of the boiler and serves as a passage for the condensed vapour. The second tube, which is the largest, is used as a conductor for the vapour to the stove. The third one, which is small in diameter, brings the vapour which can be condensed in the stove directly into the boiler. The condenser is bound to the enclosures by tubes provided with junctions.

3. The calorimeter is composed of two concentric vessels supported on a wooden stand with square columns, and on one of them is placed a copper block, which serves to fix the thermometer. Under this support there is screwed a copper carrier, which slides on a guide of the same metal fixed to the table of the apparatus. A sliding wooden screen intercepts the radiation of the rest of the apparatus from the calorimeter. A chair suitably placed supports the stoves, and a support connected with the table serves to fix at a convenient height the apparatus for producing the vapour.

The body to be studied is placed in a small metallic basket suspended in the middle of the central tube of the stove ; a thermometer indicates the temperature of this part of the apparatus. When the moment has come for bringing down the body into the calorimeter the screen must be lifted up, and the carrier which supports the thermometer made to slide on the copper guide until it reaches a certain point fixed on the guide. With one hand the basket is let slip, and with the other the detent of a rapidly acting spring appliance is released. The body being thrust into the calorimeter it must be brought back to its former position and the screen then lowered. This apparatus, which is easily worked, enables M. Regnault's experiments on this subject to be repeated most accurately.

1058c. Jamin's Calorimeter. *L. Golaz, Paris.*

This instrument, made for the designer, is constructed on the same principle as M. Favre's, but being only used for demonstrations its construction is simpler. It consists of a cylindrical vessel of glass, provided with an iron cover to which are fixed two iron tubes reaching down into the cylinder, the stem of the thermometer being placed vertically in the cover. A small glass funnel is placed over a stop-cock terminating in a capillary glass tube, which serves for filling the apparatus.

1058d. Bunsen's Absorptiometer. *L. Golaz, Paris.*

This apparatus consists of a wooden stand, to which is fixed an iron ring carrying two vertical supports, united at the top by a circle to which is fixed a plate on hinges. Along one of the columns is placed an iron tube, having at its upper end an iron funnel ; at the lower it enters the vertical opening of a three-way cock. One of the horizontal openings communicates with a chamber made in the centre of the stand, and the other communicates with an outlet ; thus it is possible either to make the mercury run into the chamber, or, by turning the cock another way, to permit it to escape.

On the upper surface of the wooden stand has been made a deep groove, at the bottom of which is fixed a washer of vulcanized india-rubber. A glass cylinder, the ends of which are perfectly true, rests in this groove, and fits the top of the stem ; the plate, which is used as a cover, is provided with an india-rubber disc, and rests on the top of the glass cylinder.

The absorption-tube is open at its lower end, and cemented into a socket made of iron, having a screw thread which fits into an iron block cut away at the sides. A rotary motion about its axis is sufficient to cause the opening or closing of this tube, an india-rubber washer being placed at the junction.

On the part of the block which is not cut away are fixed two springs of steel, which retain it in the hollow of the stand and in two diametrically opposite grooves which are placed there ; a slight friction is thus produced, permitting however the opening and shutting of the absorption tube. At the centre of the higher plate of the cover is an iron socket on which is stretched, by means of a ring screwed to it, a piece of india-rubber ; in lowering the cover the point of the tube enters into the socket, and the tube is found perfectly fixed at the centre.

1058e. Regnault's Air Thermometer. *L. Golaz, Paris.*

This apparatus is composed of a glass cylinder terminating in a capillary stem bent at right angles, and supported by a metal stand, having in its centre a tube on which is placed the stem of the thermometer. The screw adjustment, with two pointers, is used to take, by means of the cathetometer, the height of the mercury in the small glass vessel which is placed underneath the apparatus. Above is arranged a glass cylinder which serves to hold the ice in the experiment. A bent tube lets the water which runs off escape.

1058f. Regnault's Apparatus for determining Specific Heat of Liquids. *L. Golaz, Paris.*

This apparatus consists of a cylindrical copper vessel, having at its lower extremity a lateral conical appendage. In the axis of the vessel there is a cylinder of brass which receives the liquid to be experimented upon, and which is furnished at its upper part with a vertical tube, into which is inserted a thermometer, giving the temperature of the liquid. The cylinder terminates in a stop-cock inclined downwards, and having at its lower extremity a tube which, after having traversed the conical space, is soldered to the cylinder, enters the tube of the calorimeter at the other side of the stop-cock, and terminates in a tube which goes through the wall of the cylinder. It is by this tube that the key of this stop-cock enters, it being worked from the exterior. A hole made in the hand of the key establishes a current of air which drives the liquid into the calorimeter, at the same time that the stop-cock is turned for that purpose.

A double wooden screen, fixed perpendicularly, cuts off all radiation from the vessel which is being heated or from the calorimeter. Two iron arms fixed to the upright of the screen support the vessel at such a height that a gas burner may be placed underneath.

The calorimeter consists of a brass cylinder, into which passes the liquid experimented on, and of a flat vessel containing a thin screw-shaped blade for the purpose of condensing the vapour which might be generated by the liquid in the vessel. A brass receptacle surrounds this first calorimeter, a second one, resting upon feet made of wood or cork, surrounds the first. The height and the position which must be given to the calorimeter are regulated by a stand with a movable column. The description of the experiments with this instrument is to be found in "Mémoire de l'Académie," tome 26, page 262.

This apparatus is constructed of glass, copper, or platinum, according to the nature of the liquids upon which it is desired to operate. The one exhibited is made of platinum.

1058g. Favre's Mercury Calorimeter.

L. Golaz, Paris.

This apparatus consists of a large spherical reservoir of cast-iron, resting on a support of iron, surrounded with a non-conducting substance. Underneath is made a vertical opening, through which a steel piston passes, being set in motion by a screw provided with a winch-handle. Near the centre of the sphere there is a cast-iron tube on which is screwed a steel stop-cock, terminating in a small glass ball, to which is fitted a carefully calibrated horizontal thermometer. The graduations on the stem of this thermometer correspond with its interior capacity; it is supported by two wooden columns, which rest upon a solid bench opposite the stem, and on the corresponding side are two iron tubes, placed obliquely with regard to the vertical diameter of the sphere. These two tubes, called "mouffles," are immovably fixed to the iron sphere, and extend to its interior. They are thus completely surrounded with mercury when the reservoir is full, an operation which is very easily accomplished by means of two stop-cocks placed opposite to the plunger. A small glass pipe of a particular shape is used for bringing liquids into the "moufles." The divisions on the stem of the thermometer are read by means of a micrometer. To protect the large bulb of the thermometer from the influence of the temperature of the exterior, it is surrounded by a wooden box, in which is placed flannel and swan's down.

1060. Thermometric Tube for determining the calorific capacities of different liquids. *Elie Wartmann, Geneva.*

A thermometric tube, being part of the exhibitor's apparatus for the determination of calorific capacities in liquids. A full description of the method is printed in the number for May 1870 of the "Archives des Sciences physiques et naturelles." An electric chronoscope, such as Sir Charles Wheatstone's, expresses in thousandth parts of a second the time necessary for the cooling between two constant temperatures of the same body (the thermometric tube) when immersed in equal volumes of different liquids, at the same initial degree of heat.

1061. Apparatus made by De la Rive and Marcet for measuring the specific heat of Gases. A small copper calorimeter, containing a very thin serpentine gold pipe.

Lucien de la Rive, Geneva.

1063. Drawing of an Apparatus for determining the calorific capacity of liquids.

Dr. Leopold Pfaundler, Professor of Physics at Innsbruck.

In a box protected against draught there are placed two calorimeters—one filled with water, the other with the liquid to be tested. An electric current is passed through the two spiral wires, of equal resistance, which are inserted in the fluids.

Two paddles stir the liquids, and two thermometers measure the temperature.

The respective capacities for heat are calculated from the proportion of the increment of heat.

V.—RADIATION.

1056. Hargreaves's Thermo-radiometer, for measuring loss of heat by radiation from walls of furnaces, sides of steam boilers, &c. *James Hargreaves.*

The silver-plated copper vessel is filled with water and enclosed in the case, the blackened face then being exposed for a given time (say five minutes) to the radiating surface, a thermometer inserted in the neck of the vessel shows the elevation of temperature due to radiation. The heat is calculated as follows, either in calorics or British thermal units. $\frac{WS(T-t)}{a\,m} = x$. Where WS = weight and average specific heat of vessel and its contents; t, temperature of the same before exposure; T, temperature of the same after exposure; a, area of blackened face of vessel; and m, time of exposure, whence may be calculated the amount of fuel necessary to replace the heat lost by radiation.

1062. Apparatus used in researches on the **Absorption** of **Radiant Heat** by gases and vapours.

Prof. Tyndall, F.R.S.

Phil. Trans., 1861.

1065. Pair of concave Reflectors of Prima German silver, 500 mm. in diameter, on brass stands, with supports for carbon and tinder, for experiments on radiant heat.

Warmbrunn, Quilitz, and Co., Berlin.

1066. Melloni's Apparatus for the investigation of the laws of radiant heat. *H. Lloyd, Trinity College, Dublin.*

1072. Pouillet's Actinometer, for sidereal radiation.

Conservatoire des Arts et Métiers, Paris.

1072a. Actinometer, for measuring the intensity of Solar Radiation. *J. Louis Soret, Geneva.*

It is composed of a tube, of the diameter of about 35 millimetres, closed at one end, and blackened inside. The end, which can be opened by removing the stopper, is furnished with a diaphragm. The central tube is encircled with a concentric brass wrapper, which has to be filled up with pounded ice, or with snow. The apparatus is upheld by a horizontal axle upon a wooden support. This axle is formed of a tube which, on one side, lets out the rod of the thermometer (lacquered and blackened), and on the other may be adjusted to an air-exhausting pump. The apparatus is directed towards the sun; the orientation is obtained by means of the exterior appendiculæ.

See "Recherches sur l'intensité calorifique de la radiation solaire.—Comptes Rendus de l'Association Française pour l'Avancement des Sciences," 1st Session, Bordeaux, p. 282.

1072b. Actinometer.

M. Desains, Member of the Institute, Paris.

1073. Pouillet's Pyrheliometer, for observations on solar heat. *Conservatoire des Arts et Métiers, Paris.*

VI.—ABSORPTION.

1084. Ice-making Machine; system of Raoul Pictet & Co.

Raoul Pictet & Co., Geneva. Geneva Association for the Construction of Scientific Instruments.

This machine manufactures ice by means of anhydrous sulphurous acid. This substance has the following advantages:—

1. It is without action upon metals and fatty substances.
2. It gives but slight pressures, never exceeding 4 atmospheres in a temperature of 30° centigrade.
3. It is free from all danger of ignition or explosion.
4. It is the least expensive volatile liquid.

This machine turns out 12 kilogrammes of ice per kilogramme of coal consumed.

1085. Apparatus for Freezing Water, constructed by Mr. Bieberich. Compare the adjoined instruction for use.
University of Munich (Prof. v. Jolly).

1086. Small Ammonia Ice Machine.
Vaast and Littmann, Halle.

VII.—CONDUCTION.

1091. Despretz's Apparatus for showing the **Conduction of Heat** in metals with 9 thermometers.
Warmbrunn, Quilitz, and Co., Berlin.

1090a. Three Original Bars, by **Despretz,** used in his experiments upon the **Laws** of **Conductivity.**
The Faculty of Sciences, Paris.

1088. Forbes' Iron Bar for **Thermal Conductivity,** with its crucible. *Prof. Tait.*

1089. German Silver Bar, of same size, cast for same purpose. *Prof. Tait.*

1059. Diacalorimeter. To measure the resistance which liquids offer to the passage of heat. *Frederick Guthrie.*

Two conical platinum vessels, having their bases accurately plane, are supported so that their bases are parallel, horizontal, and nearly in contact. The lower cone is fixed, and, being provided with a vertical tube fitting air-tight in which water stands at a known height, serves as an air thermometer and calorimeter. The upper cone can be adjusted by a micrometer screw at any distance from the lower one. Through the upper cone a current of warm water or steam is passed. Between the bases of the cones is introduced the liquid whose thermal resistance is to be measured.

1092. Ingenhousz's Apparatus for demonstrating the **Conduction of Heat,** with nine rods of different metals.
Warmbrunn, Quilitz, and Co., Berlin.

1093. Apparatus intended to produce the **Curves** of **Thermic Conductivity** on the surface of bodies.
M. Jannetaz, Paris.

On the glass support are placed plates coated with grease, which may be coloured. The current of a battery is made to pass through the small platinum ball, which is at the end of wires of the same metal, and which are put into contact with the plate.

1093b. Four Boxes, containing plates subjected to the action of the above apparatus, and showing the isothermic curves produced by the fusion of the grease upon—

A. Bluish schist, from the valley of Sulvan, near Vernagaz.
B. Coal schist, from neighbourhood of Motivon, near the Col de Voza.
C. Another schist from the Col de Voza.
D. Septypite from Tholy (Vosges).
E. Clayey schist.
F. Hyaline quartz, with faces cut parallel with the axis.
G. Trooshte, silicate of zinc, with faces cut parallel with the axis.
H. Gneiss, fine grained, from the Val Anzasca, Monte Rosa.

M. Jannetaz, Paris.

VIII.—POLARISATION.

1095. Forbes' Mica Plates for the polarisation of heat by refraction. *University of Edinburgh.*

The mica is split into numerous thin films by careful application of heat, and fixed in the wooden tubes at the proper polarising angle.

IX.—MISCELLANEOUS.

Lens of Benedetto Bregans, 42 cm. in diameter, given to the Grand Duke Cosimo III. after 1690. With this lens Avesani and Yargioni, 13 years after the extinction of the Accademia del Cimento, made the well-known experiments on the combustion of the diamond and other precious stones. Afterwards it served the celebrated Sir Humphry Davy for his researches on the chemical constitution of the diamond.

The Royal Institute of "Studii Superiori," Florence.

Plaster Model of Thermodynamic Surface.

Prof. J. Clerk Maxwell.

1097. Apparatus employed by **Professors Stewart** and **Tait** for producing rapid **Rotation** in a **Vacuum.**

Prof. Balfour Stewart.

The driving shaft is of iron, and passes into the receiver through an iron tube containing mercury, which acts as a barometer.

This instrument was constructed and in part devised by R. Beckley, of the Kew Observatory, for an experiment conducted by B. Stewart and P. G. Tait. The mechanical principle of its construction is as follows :—The receiver in which the rotation takes place is in fact the extended vacuum of a barometer. Through the mercury of this barometer a shaft communicates a slow motion to some machinery in the receiver. The velocity of this motion is there greatly increased by means of a suitable train of wheels, until at length a vertical disc is made to rotate with great rapidity on a horizontal axis. If this disc be made to rotate in an ordinary obtainable vacuum it will become heated, and the question is to determine whether this heating of the disc is entirely due to the friction of the residual air, or to something else.

Two wires, covered with gutta percha, carried through the bed-plate of the apparatus, convey into the receiver a thermo-pile arrangement, by means of which the temperature of the disc may be measured. This thermo-pile may either measure the increased temperature of the disc after rotation by radiation—in which case it is fitted with a reflecting cone ; or it may be made to tap the surface of the disc after rotation—in which case there is an arrangement working through a barometric tube, by means of which the pile may be brought up to the disc in vacuo after rotation. Finally, there is an arrangement, working also through a barometric tube, by means of which a vessel containing some peculiar chemical substance may be uncovered in vacuo at will. The object of this is to reduce the pressure of the vacuum by chemical means. For instance, if we have a carbonic acid vacuum made as low as it can be made by ordinary means, a vessel containing moist potash would be uncovered, and a great part of the residual gas absorbed. The experimenters by this means have obtained a vacuum as low as 0·025 in. The conclusion from these experiments appears to be, that there is a certain heating of the disc which does not depend on the residual air.

1098. Effects of Heat on Nature. 9 Sénarmont crystals for heat. *Laurent.*

1100. Automatic Fire Extinguisher and Alarm. For ships, factories, and all places where steam apparatus is employed. *Sanderson & Proctor.*

The action of the apparatus is as follows :—

Thermometers are fixed on the ceiling or elsewhere in the room, and are set to complete an electric circuit at a given degree of heat, each thermometer being in connexion with a galvanic battery and electro-magnet. A steam valve is also fixed in the room, communicating with the valve at the boiler. As soon as a fire breaks out, and raises the temperature of the nearest thermometer to the given degree, the electric current is complete, and the electro-magnet, by a very simple contrivance, opens the steam valve in the room and the valve at the boiler, the steam rushes into the room at the existing pressure of the boiler and effectually extinguishes the fire. Simultaneously with the action of the electro-magnet, an electric alarm and indicator are set in motion, thus giving prompt notice of the fire, and indicating its position.

1101. Prism of Rock Salt, 50 × 60 mm. *W. Steeg, Homburg vor der Höhe.*

1102. Lens of Rock Salt, 75 mm. in diameter, and 300 mm. in radius. *W. Steeg, Homburg vor der Höhe.*

1103. Plate of Rock Salt, 60 × 60 mm. *W. Steeg, Homburg vor der Höhe.*

1104. Diagram of the **Thermodynamic Relations of Aqueous Vapour** for pressure up to 30 atmospheres. *Oberbergrath E. Althaus, Breslau.*

These diagrams have appeared on a smaller scale, and accompanied by a memoir entitled : The Boiler Systems for High Pressure, and their Application to Mining Engines, Part III., in the " Zeitschr. für das Berg-, Hütten-, und

"Salinenwesen, im Preussischen Staate. Herausg. im Minist. für Handel, "Gewerbe, und öffentliche Arbeiten. XXIII. Bd., 5 Lief."

1104a. Two Photographs, representing the **Thermo-ventilator** when open and closed. *M. Wellesen, Christiania.*

This instrument, which is useful as a means of promoting health, consists of five parts, comprising a regulating balance for heat, and a valve for fresh air, which is self-closing, and can keep out the cold. The smaller part of the iron and brass tube (to which a foot or stand is fixed for exhibiting purposes) gives a clear idea of the system by which the thermo-ventilator is applied to the internal orifice of the atmospheric tube.

1105. Apparatus of sheet metal, constructed by the exhibitor, for demonstrating the **Causes of Disturbances in the Draught in Chimneys,** as well as the influence of wind and weather. It is at the same time a means of studying the general motion of air produced by heat (ventilation). Compare the adjoined description. *Prof. Dr. Meidinger, Carlsruhe.*

1105a. Apparatus for quickly communicating a **Given Temperature** to a **Liquid,** and to maintain it at this temperature. *W. Gloukhoff, Warden of Russian Standard Measures.*

It is used in the determination of the density of the liquids; for the verification of alcoholometers, hydrometers, &c.; at normal, or any other temperature. The principal part of this apparatus is a cylindrical metallic stirrer, immersed in the liquid to be experimented upon, contained in a very solid glass cylinder. The warm or cold water, poured in small quantities, in the interior hollow space of the stirrer, by means of a glass funnel introduced in one of the two metallic tubes communicating with the hollow space, and a few movements up and down of a stirrer, will very quickly warm or cool the liquid, and thus bring it to a determined temperature. The syphon, introduced in another tube, serves to empty the stirrer. In the glass disc, covering the glass cylinder, are two apertures: the large one, for weighing solid bodies in liquids, immersing in it the hydrometers, &c.; and the small one for a thermometer to determine the temperature of the liquid.

1105b. Apparatus for keeping a **Constant Temperature** in an air or water bath.

The Secondary Government School, Assen (Netherlands).

This gas regulator, constructed after the design of Dr. A. Van Hasselt, teacher at the school for middle-class education at Assen (Netherlands), was made principally by J. Van Rossum, servant in the laboratory.

The air thermometer, connected with the regulator and with a large Bunsen cell, is partially filled with mercury, so that only the upper bulb and a great part of the tube contain air.

When the desired temperature has been reached, the wire of platinum is screwed down, so as to reach the mercury, at which moment a current from the cell passes. This current passes through the wire, which is coiled round the iron tube in the apparatus, through which the gas is flowing, and which is used as an electro-magnet.

The little iron valve on the side of the tube, covered with a thin plate of caoutchouc, which now shuts the tube, has a small aperture, which lets pass gas enough to prevent the lamp from being extinguished.

SECTION 9.—MAGNETISM.

WEST GALLERY, GROUND FLOOR, ROOM F.

I. NATURAL MAGNETS.

Natural Magnet, mounted by Galileo, weighing six ounces. He presented it to the Grand Duke Ferdinand II. del Medici. It is made in the shape of an urn and holds a weight of ten pounds. *The Royal Institute of "Studii Superiori," Florence.*

Galileo was the first to arm natural magnets, and thus succeeded in making them bear very much greater weights; he proved, at the same time, that the same loadstone can bear a greater weight when in several pieces than when it is in one block; and that moreover its attractive power can be increased by loading it by degrees with an increasing weight.

Natural Magnet, armed by the Accademia del Cimento. *Accademia del Cimento.*

The members of the Accademia del Cimento found that the power of this magnet was not lost by passing through very many substances; and that its attractive force varied according to its position with regard to the poles of the earth.

1106. Great Natural Magnet; one of the largest known. *See* Lamont, "Handbuch des Magnetismus," 1867, p. 107. *Teyler Foundation, Haarlem.*

Weight, with the armature - -	152 kilograms.
Force - - - - -	114 „

1107. Natural Magnet, mounted in brass case, with steel poles, and soft iron keeper. *Elliott Brothers.*

1107a. Natural Loadstones (two), Russian, in perforated and painted metal cases. *Bennet Woodcroft, F.R.S.*

II. PERMANENT ARTIFICIAL MAGNETS.

1108. Collection of Artificial Magnets, lately forged by M. Van Wetteren, and magnetised at Teyler's Museum. *Teyler Foundation, Haarlem.*

A. Single magnet, weight 2·17 kilogr.; greatest original force, 51·3 kilogr.; permanent force, 35·9 kilogr.

B. Compound magnet. No. 3,053. Weight, 1·52 kilogr.; greatest original force, 36·4 kilogr.; permanent force, 27·7 kilogr.

C. Two single magnets. No. 3,003. Weight, 0·51 kilogr.; greatest primitive force, 19·5 kilogr.; permanent force, 12·4 kilogr. No. 3,005. Weight, 0·52 kilogr.; greatest original force, 18·6 kilogr.; permanent force, 13·7 kilogr.

A third open keeper with movable side plates.

The box, C, forms a school apparatus, to demonstrate the effect of mutual contact of the magnets, and of the constitution of the keeper, on the distribution of free magnetism, on the weight that can be suspended, and on the deflections of the needle produced by the magnet when open, and when more or less closed.

See the memoir of Prof. Van der Willigen, which will soon appear in the Archives du Musée Teyler.

1109. Great Artificial Magnet, forged and magnetised in 1850 by Messrs. Van Wetteren and Logemann, according to the directions of Dr. Elias, whose property it is.

Teyler Foundation, Haarlem.

Newly magnetised at Teyler's Museum.

Weight - - - - -	28 kilograms.
Original force - - - -	260 ,,
Permanent force - - - -	200 ,,

1109a. Large Artificial Magnet made of thin Plates.

M. Jamin, Paris.

1110. Photograph of a Horse-shoe Magnet, made by Johann Dietrich, of Basle, in 1755.

Prof. Hagenbach-Bischoff, Director, The Physical Institute in the Bernoullianum, Basle.

1111. Permanent Bar Magnets (pair of), in case.

James How & Co.

1112. Compound Horse-shoe Magnet. *James How & Co.*

1112a. Series of Permanent Magnets, bar form, in wooden cases for students. *Harvey, Reynolds, and Co.*

1113. "Logemann's" Magnet, being a powerful battery of steel-plate magnets. *Frederick Guthrie.*

1113a. Magnets by M. Jamin. *M. Bréguet, Paris.*

1113b. Magnet, Jamin's, with plates 0·05 m. in width.

M. Breguet, Paris.

1113c. Large Artificial Magnet, and fittings.

M. Jamin, Paris.

III. ELECTRO-MAGNETS AND ELECTRO-MAGNETIC ENGINES.

1115. Large Electro-Magnet, for showing magnetism and diamagnetism. *Elliott Brothers.*

1115a. Small Electro-Magnet by M. d'Obelliane, bearing thirty times its own weight. *Polytechnic School, Paris.*

1116. Three Electro-Magnets.
The Committee, Royal Museum, Peel Park, Salford.

One of which is a circular plate, 4½ inches diameter; another, a plate 4¼ inches square; and the third, 4 inches, with one armature; the 4-inch magnet will sustain a load of 1,400 lbs. to 1,500 lbs. Made by the late R. Roberts, C.E., of Manchester.

1117. Powerful Electro-Magnet.
The Committee, Royal Museum, Peel Park, Salford.

Of the horse-shoe form, with an elliptical section. Made by the late R. Roberts, C.E., of Manchester.

1118. Surface Electro-Magnet made in 1840. When fully excited, the armature is retained with a force of upwards of a ton. *J. P. Joule, D.C.L., F.R.S.*

1119. Electro-Magnet, on **Joule's Construction,** mounted so as to serve for supporting weights, or for experiments on Diamagnetism. *Dr. Stone.*

1119a. Electro-Magnet, by Repmann.
M. Breguet, Paris.

1119b. Electro-Magnet, by Jablochkoff.
M. Breguet, Paris.

1119a. Small Electro-magnet. *H. L. Rutter.*

1120. Tubular Electro-Magnets. *John Faulkner.*

In this system iron cases are used, of such size and thickness as ensures the utilisation of the maximum magnetic effect.

The object is to accumulate and utilise all or a portion of the electric power, and thereby when desirable prevent the loss that takes place in electro-magnets usually employed in electrical appliances.

1121. Diagrams (30), illustrating the **Great Waste** of **Power** in **Electro-Magnets** as heretofore made, and the economy of tubular electro-magnets. *John Faulkner.*

These diagrams are produced by scattering iron filings upon paper, prepared with paraffin, placed above ordinary electro-magnets and improved electro-magnets respectively.

1122. Objects illustrating the applications of tubular **Electro-Magnets.** *John Faulkner.*

1. A. Electro-magnets; various.
2. B. Electric bells; various.
3. C. ,, indicators; various.
4. D. ,, semaphore actuators; various.
5. E. ,, telegraph sounders; various.
6. ,, ,, ,, key and sounder on one base.
7. ,, ,, ,, ,, ,, separate.
8. ,, ,, ,, sounder with movable cover.
9. ,, ,, ,, ,, with movable core.
10. ,, ,, ,, ,, with movable coil.
11. F. ,, brass and iron separators.
12. G. ,, pottery glaze iron extractors.

In the sounders a movable cover of wire is made partially or totally to cover the coil by means of a regulating screw. In case of partial failure of the battery, the instrument can be increased in power by a suitable alteration of the position of the wire cover.

1123. Froment's Engine. An electro-magnetic machine depending upon the successive attraction by fixed electro-magnets of bars of soft iron fastened on a wheel and parallel to its axis. *Frederick Guthrie.*

The successive magnetisation and demagnetisation of the magnets is effected by the action of cams on the axis of the wheel, which lift ivory rollers, and so displace springs to which they are fastened.

1124. Helmholtz's Electro-magnetic Engine.
F. Rob. Voss, Berlin.

The advantage of this machine is that it is set in motion by a very small galvanic force; with two Bunsen elements it will drive one of Professor Helmholtz's double-syrens or one of his centrifugal commutators.

Professor Helmholtz has applied a contact-arrangement to the commutator of the Siemens' bobbin, which surpasses all former ones in that it avoids great surfaces of friction, thus attaining greater power and speed.

1124a. Electro-magnetic Machine, with velocity regulator. Helmholtz.
Physical Institution of Berlin, Prof. Helmholtz.

The current which drives the electro-magnetic machine is interrupted by the centrifugal regulator whenever the velocity exceeds a certain limit, whereupon the driving force ceases. Using a current which is only a little stronger than what exactly suffices for the normal velocity, exceedingly constant velocities of rotation are obtained. (Described by M. Exner in the Sitzungsberichte of the Vienna Academy, Math. Natura. section, vol. LVIII., part II., page 602.)

1125. Electro-magnetic Engine. *F. Stöhrer, Leipzig.*

1125a. Electric Motive Power, acting on a pump.
M. Loiseau, junior, Paris.

1125b. Electric Motive Power, acting on a jet of water.
M. Loiseau, junior, Paris.

1125c. Electric Motive Power, acting upon a hammer.
M. Loiseau, junior, Paris.

1125d. Electric Lighting Apparatus.
M. Loiseau, junior, Paris.

1125e. Electric Telegraph. *M. Loiseau, junior, Paris.*

1401. Electro-Magnetic Gyroscope, with double motion.
G. Trouvé, Paris.

1125f. Electro-Magnetic Machine, invented by Sir Charles Wheatstone. *The Council of King's College, London.*

1125g. Electro-Magnetic Engine, patented by Thomas Allan, No. 14,190, A.D. 1852; and No. 2,243, A.D. 1854.
H.M. Commissioners of Patents.

This engine is so constructed that when set in action several electro-magnets are formed one after the other, and give successive impulses in the same line or direction to an upright rod or bar, capable of being moved longitudinally to any desired extent.

1125h. Electro-Magnetic Machine, invented by Sir Charles Wheatstone. *The Council of King's College, London.*

1125i. Electro-Magnetic Machine, invented by Sir Charles Wheatstone. *The Council of King's College, London.*

IV. APPARATUS FOR INVESTIGATIONS CONNECTED WITH PHENOMENA OF MAGNETISATION.

1126. Apparatus showing a remarkable property of magnetised Soft Iron Tubes.
Prof. Dr. A. von Waltenhofen, Prague.

On a balance are suspended a tube and a solid cylinder, both of soft iron, the cylinder being much heavier, and therefore counterbalanced by adding a brass weight to the tube, or by filling it with shot. Both tube and cylinder are introduced into an electro-magnetic helix, fixed upright beneath the balance at the bottom of the apparatus (as in the electro-magnetic balance of Becquerel). The coils are joined so as to unite the poles of a Bunsen's cell, or any other voltaic cell of small resistance.

On completing the circuit, a suction force is exerted on the tube and the cylinder, tending to draw them into the helices. The tube or cylinder will then appear the heavier, according as the electric current possesses less or more strength. This change can be performed at pleasure by means of a Wheatstone's rheostat, introduced in the path of the current.

The theory of this phenomenon is given in the Sitzungsberichte d. k. Akademie d. Wissenschaften. Juli Heft, 1870.

1126a. Apparatus by Th. Petrouchevsky, Professor at the University of St. Petersburg, for **measuring** the distance of the **Magnetic Poles** in straight magnets from their ends.

Imperial University of St. Petersburg.

A straight magnet is suspended horizontally at a point where one of the poles is approximately supposed to be. Another straight magnet, much shorter than the first, is placed in the same horizontal plane, perpendicularly to the suspended needle. A slow movement can be given to this second magnet along a divided scale, horizontal and parallel to the suspended needle. The mutual repulsive action of the two magnets is greatest when the direction of the axis of the small magnet passes through the magnetic pole sought, provided that the suspended magnet remains perpendicular to the second magnet. To fulfil this condition an auxiliary magnet is used, which is placed on the other side of the suspended magnet, and which is to produce an equal, but contrary, effect to the second magnet. This method of finding the poles has been described in Russian in the "Messenger of Mathematical Sciences" (Wiestin), and since, in Poggendorff's Annalen, Bd. 152, s. 42. It requires the use of three distinct appliances: 1st. A bifilar apparatus for suspending cylindrical magnets. 2nd. A measuring apparatus, having a small magnet that can be moved parallel to itself while remaining perpendicular to the direction of said movement. The apparatus has two divided scales, and is supplied with a microscope, two levels, and two small telescopes of short focus. These two appliances are placed alongside, and parallel to one another, and, approximately, in the magnetic meridian. The third (No. 3) apparatus consists of a divided scale placed perpendicularly to the suspended magnet. Along this may be moved a small magnet, of which the function has been explained above. The second apparatus enumerated was constructed by Mr. Brauer, of St. Petersburg, from the designs of Professor Petrouchevsky.

1126b. Apparatus for so-called **"Normal" Magnetisation,** by Th. Petrouchevsky, Professor of Physics at the University of St. Petersburg. *Imperial University of St. Petersburg.*

An iron cylinder for magnetising, placed symmetrically in a magnetising coil, may receive very different distributions of the free magnetism, according to the length of the coil, but the distribution does not depend on the strength of the current. The inventor has discovered that the distribution of the remanent magnetism, or rather the distance between the poles, remains always the same, independently of the length of the coil or the strength of the current. At a fixed length of the coil, the magnetic poles of the electromagnet and the poles of the remanent magnetism coincide, so that the electromagnet, placed horizontally and perpendicularly to the magnetic meridian before a sensitive magnetic needle, acts upon it in the fixed direction (say, the direction of the meridian itself) during the circulation of, and after the cessation of, the current; in the latter case, the poles of the permanent magnetism act. The poles are then almost at the ends of the magnetising spiral, the length of which is about 0·8 of the iron cylinder, independently of the length and diameter of the cylinder. This arrangement of the poles of the electro-magnets is called "normal." The apparatus used in these researches are composed of two very distinct parts. The first apparatus contains two brass cylinders, surrounded with wire spirals; by turning one of these cylinders, the number of spirals can be lessened on the one, and increased on the other. Inside one of these cylinders is placed the iron to be experimented upon. This apparatus is set upon a table covered with marble plates moving in two directions, perpendicular to one another. The other apparatus is a needle, called "unipolar," suspended by means of a cocoon thread, with two microscopes.

1127. Ring of Elias for magnetising artificial magnets of large size. *Teyler Foundation, Haarlem.*

A magnet of 28 kilogrammes weight has been recently magnetised by this ring in Teyler's Museum.

Dr. Elias proposed more than 25 years ago his ring-coil for the production of artificial magnets of all dimensions, by an intense galvanic current. His artificial magnet here exhibited has lately been re-magnetised, with a slight modification of his method by Prof. Van der Willigen in the Teyler Museum, by this ring with the current of forty Bunsen elements of the usual large size.

1128. Apparatus for showing to an audience the effects of the superficial tension of liquids (Tomlinson's Cohesion Figures); magnetic curves or the movement of liquid films, &c.

Prof. W. F. Barrett.

1129. Bar of Metallic Nickel, 20 inches long and ½ inch diameter. *George Gore, F.R.S.*

1130. Three Plates of Metallic Nickel, 6 inches long and 1½ inch wide. *George Gore, F.R.S.*

1131. Small Nickel Horseshoe, for making a Nickel Magnet. *George Gore, F.R.S.*

1132. Plate of Metallic Cobalt, 6 inches long and 1½ inch wide. *George Gore, F.R.S.*

1135. Horseshoe Magnet of **Nickel,** used by Sir William Thomson in his experiment on the effect of magnetism on the thermo-electric quality of nickel. Result published in the Transactions of the Royal Society for the year 1856, Bakerian Lecture.

Edinburgh Museum of Science and Art.

1136. Apparatus for showing a series of molecular and magnetic changes in a red-hot iron bar; and designed also to show the influence of traction, compression, and torsion upon such changes. The latter experiments have not yet been made with it.

George Gore, F.R.S.

See Philosophical Magazine, Sept. 1870.

1136a. Apparatus for exhibiting molecular changes occurring during the heating and cooling of iron wire.

Prof. W. F. Barrett.

When an iron or better a steel wire is raised to a white heat, a sudden contraction occurs at a dull red heat, the apparatus exhibits the phenomenon first noticed by Mr. Gore; when the wire is allowed to cool after being raised to a white heat a corresponding expansion at a red heat was found by Prof. Barrett, who also discovered that at this moment a crepitating sound was emitted, the wire resumed its magnetic state at this period, and furthermore, a sudden reglowing of the wire takes place. These phenomena at this critical temperature are also associated with changes in the conductivity and thermo-electric property of the wire, as discovered by Prof. Tait. *See* Phil. Mag. Dec. 1873, Jan. 1874, and Report Brit. Ass., 1875, p. 259.

1136b. Apparatus designed by G. Gore, F.R.S., for exhibiting the effects of stress upon the magnetisation of iron.
Prof. W. F. Barrett.

1136c. Gore's Apparatus for exhibiting the torsion of an iron wire produced by axial and transverse magnetisation.
Prof. W. F. Barrett.

1136d. Apparatus and Diagrams, to illustrate the elongation of unstrained iron produced by magnetisation.
Prof. W. F. Barrett.

1137. Coulomb's Torsion Balance for magnetic and electric observations. *Warmbrunn, Quilitz, and Co., Berlin.*

1137a. Electro-Magnetic Helix, on wooden tube. Used in electro-torsion experiments. *George Gore, F.R.S.*

1137b. Two Wooden Tubes, upon which to form electromagnetic helices for electro-torsion experiments.
George Gore, F.R.S.

1138. Apparatus for the **demonstration** of **Magnetic Friction,** constructed by the late M. Kleemann in Halle.
Prof. Dr. Dove, Berlin.

V.—APPARATUS FOR INVESTIGATIONS CONNECTED WITH DIAMAGNETISM.

1139. Glass Tubes prepared by **Faraday** for testing the magnetic and diamagnetic character of **Gases.**
The Royal Institution of Great Britain.

The tubes containing the gas to be examined were suspended in the magnetic field of a powerful magnet, the result being either attraction or repulsion of the tubes as the gases they contained were either magnetic or diamagnetic.—Phil. Trans., 1850.

1140. Bars of Borate of Lead Glass, made and used by **Faraday,** for the action of magnets on polarized light.
The Royal Institution of Great Britain.

Phil. Trans., 1845.

1141. The Diamagnetic Box of Michael Faraday, containing spheres, cubes, and bars of diamagnetic metals; tubes of various liquids, bars of borate of lead, glass, various crystals, cradles, supports, &c., used by Faraday in his researches on diamagnetism. *Prof. Tyndall, F.R.S.*

1142. Instrument used in researches on the **Polarity** of the **Diamagnetic Force.** *Prof. Tyndall, F.R.S.*

Phil. Trans., 1856.

1143. Specimen of "Faraday's Heavy-glass." *George Gore, F.R.S.*

1144. Electro-Magnet for Induction and Diamagnetic Experiments, made in 1850, of a broad plate of annealed iron, so as to obtain a large induced power from a small voltaic source. *J. P. Joule, D.C.L., F.R.S.*

The coil is composed of a bundle of copper wires, and has a resistance about equal to that of a Daniell's cell, exposing a surface of one foot square.

1144a. Large Diamagnetic Apparatus, with glass case, rods, &c. *Warmbrunn, Quilitz, & Co., Berlin.*

1143a. Magnetic Bench, for showing the **Rotation of the Polarized Ray.** *Dr. W. H. Stone.*

1144a. Electro-Magnet, for showing the rotation of a polarised ray. *Dr. Stone.*

1144b. Vacuum Tubes (2), to show the rotation of the spark round the magnetic poles. *Dr. Stone.*

VI.—APPARATUS FOR THE OBSERVATION AND REGISTRATION OF THE TERRESTRIAL MAGNETIC ELEMENTS.

DIP AND INTENSITY INSTRUMENTS USED IN MAGNETIC SURVEYS ON SHORE AND AT SEA.

EXHIBITED BY THE ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

1145. Dip Circle for observations at sea, fitted with special arrangements for finding the magnetic meridian. By Nairn and Blunt; date, 1772–1834.

This instrument may be considered as intermediate in construction between that made by Nairn for Captain Phipps, in his voyage towards the North Pole in 1773, and the Fox circle introduced by Mr. R. W. Fox in 1834, hereafter described.

It is suspended by an universal joint, from a wooden stand carrying one adjusting screw. The needle, 9 inches long, with steel axles, vibrates within a circle graduated to 20′, and the ends of the axis are fitted to work in the agate holes of two adjustable screws in the vertical bars supporting the circle, and otherwise strengthening the instrument. The sliding pointers on the graduated circle are intended to be adjusted to the mean position of the needle when the motion of the vessel causes it to vibrate on either side of the dip. The screw on the under side of the circle works the metal supports on which the needle is placed until adjusted in the agate holes. A thermometer graduated to −38° is placed inside the instrument.

The peculiar arrangement for ascertaining the magnetic meridian consists of a small compass gimballed at the end of a wooden arm. The other end of this arm has a brass fitting to fix on pins in the graduated circle on the top of the frame. The motion of the arm in azimuth causes the whole apparatus to move in the wooden stand until the Dip Circle is in the magnetic meridian, as indicated by the compass.

1146. Dip Circle and Intensity Apparatus. Fitted with arrangements for ascertaining the magnetic meridian by three methods. By Dollond; probable date, 1776–1834.

The Dip Circle is made after the pattern described by the Hon. Henry Cavendish in the Phil. Trans., vol. xlvi., in which the dipping needle rolls upon horizontal agate planes, and a contrivance is applied for lifting it off and on to the agates at pleasure. A milled headed screw works this lift, and an adjacent butterfly screw, an arrangement for causing the needle to vibrate. The vertical circle is graduated to 20′; the outer circle of the base plate is also graduated to every 45°.

The direction of the magnetic meridian may be ascertained by two methods other than that usually adopted:—1. An edge bar horizontal needle fitted with an agate cap may be placed on the steel point fixed to a balanced axis provided for placing on the agates like the dipping needles. The coincidence of this needle with the plane of the vertical circle shows the latter to be in the magnetic meridian. 2. The same edge-bar needle can be placed on a pivot screwed in the centre of the graduated circle at the bottom of the travelling box.

Of the three dipping needles, two are flat and one cylindrical and sharply-pointed. The axes are made of gun metal, and one of the flat needles is fitted with a brass cone on Mayer's principle.

Intensity Observations.—For this purpose the box which carries the dip circle is fitted with two apertures filled with glass, and a torsion circle on the top. The two flat needles, one of gun-metal for eliminating torsion, and the other for horizontal vibrations, have metal pins screwed into the centres by means of which they are attached to the stirrup suspended by silk fibres from the torsion circle. The vibrations are observed through the glass sides, and the magnetic meridian by the edge-bar horizontal needle before described.

This apparatus closely resembles that used by David Douglas on the north-west coast of America and the Sandwich Islands in 1829–34.

1147. Dip Circle. By Robinson; date, 1830–75.

In this circle the needles are 6 inches long, flat and pointed. They move on agate planes in the centre of a graduated circle, and observations are read off by means of lenses fixed in the ends of a moveable arm centred on one of the glass sides of the instrument.

The advantages of this form of dip circle are:—1. That both the needles can be read off for nearly every angle of dip. 2. Portability, from compactness of stowage in the box, as the vertical circle is fitted so as to be readily detached from the horizontal.

An instrument of this kind was used by Major Estcourt during the survey of the river Euphrates in 1836.

1148. Dip and Intensity Circle invented by R. W. Fox, F.R.S. By Mr. George, of Falmouth ; date, 1834–75.

The principal object of this instrument is the observation of Dip and Intensity at sea, and when placed on a properly constructed gimballed table this can be accomplished, except in very bad weather.

The needles are flat, tapering from the axis to a point, and 6·9 inches long. The axles are finely pointed, and work in the jewelled holes fitted to the bracket and centre of a concentric disc in the back of the instrument, which also carries the bracket. The grooved wheel on the axis is used for carrying the hooks and deflecting weights in intensity observations. In the holes in the cross arms of the verniers at the back of the circle, the deflectors, N and S, are screwed for dip and intensity observations, and are set at any required angle by means of the graduated circle. Of the two large thumb screws in the back of the moveable disc, one works the bracket when mounting the needle and vice versâ ; the other works the clamp. At other times they are used in conjunction for the purpose of moving the disc when altering the bearings of the needles in the jewels. The pointed projection between these screws, when rubbed by the ivory disc, opposes the effect of friction in the needle and jewels.

The needles are packed in metal cases with screw ends, and may thus be used as deflectors.

Instruments of this construction have been largely and successfully used in the various magnetic surveys made at sea in H.M.'s ships.

1149. Hansteen's Intensity Apparatus ; date, 1819–50.

This form of intensity apparatus is that first adopted by M. Hansteen in his magnetic survey of Norway and the Baltic shores in 1819–24, and since largely used by various observers. The vibrating needle is cylindrical, pointed at the ends, 2·65 inches long and 0·15 inches in thickness. It is suspended from the moveable pulley at the end of the brass tube by a fibre of silk secured to a brass strap and loop in its centre. By means of the pulley the needle can be adjusted to the required height in the vibrating box.

The value of the observations depends on the permanency of the magnetic condition of the needle.

1150. Portable Magnetic Dip Circle, 3½ in. needle, made for, and used by, the late Sir John Shuckburgh. The dividing is very fine, and believed to be Ramsden's. *G. J. Symons.*

GENERAL.

1176. Photograph of an Inclinatorium (Dip Circle), by Daniel Bernoulli, completed by Johann Dietrich of Basle, in 1751.
Prof. Hagenbach-Bischoff, Director, The Physical Institute in the Bernoullianum, Basle.

This instrument gained the Prize of the Academy of Paris in 1743.

1177. Dip Circle, for determining the magnetic inclination, adapted to needles of various lengths. (Barrow, London.)
H. Lloyd, Trinity College, Dublin.

1178. Theodolite Magnetometer, 9-inch circle, and collimator magnets. (Jones, London.)
H. Lloyd, Trinity College, Dublin.

1179. Dip Circle or inclination compass. *James How & Co.*

1180. Magnetometer, Kew pattern, constructed to determine the magnetic axis and the magnetic moment of a magnet, and the direction and intensity of the magnetic force of a given place.
Elliott Brothers.

The instrument consists of two distinct parts. For the observations of the deflection magnet, the copper box screwed to the centre of the azimuth circle is used; underneath this passes, through the centre, a divided metal bar with a vernier carrying a magnet; at right angles to this bar is the observing telescope. The hollow vibration magnet, with a scale on glass at one end and a collimating lens at the other, is observed through another telescope. The latter magnet is suspended in the mahogany box above the copper box.

1184. Declinometer for sea and land observations.
Carl Bamberg, Berlin.

The instrument is furnished with gimbals for use at sea, but may be fixed for observations on land. The magnetic system, which is provided with a mirror, oscillates upon a point, and is constructed for reversal; the adjustment is effected by means of a collimator telescope, and orientation from terrestrial and astronomical objects.

1185. Deviation Magnetometer, for determining the magnetic relations on iron vessels. *Carl Bamberg, Berlin.*

The deviation magnetometer enables determinations of deviation (horizontal and vertical) to be read off on points, and also determinations of horizontal and vertical intensity by oscillations and deviations. A small telescope serves for determining orientation from terrestrial and astronomical objects. The instrument may be mounted on the same stand as the compasses.

1190. Drawing of a Dip Circle. *J. P. Joule, F.R.S.*

The needle, constructed of a thin ribbon of annealed steel, weighing 20 grains, is furnished with an axis made of a wire of standard gold. This axis is supported by threads of the Diadema Spider attached to the arms of a balance suspended by a fine stretched wire. The whole is hung by a wire which can be twisted at the head through 180°. At the bottom is attached a paddle immersed in castor oil, which brings the instrument speedily to rest in a fresh position. The deflections are read off by a short-focus telescope, placed on an arm revolving on an axis in the centre of the circle. With this instrument the dip can be determined within the fraction of a minute of a degree in less than a quarter of an hour.

With this drawing is exhibited a specimen of the THREAD of the DIADEMA SPIDER, also THREAD of the DIADEMA SPIDER COCOON.

1191. Portable Unifilar Magnetometer. An instrument for determining the horizontal intensity of terrestrial magnetic force; and also the declination.

Kew Committee of the Royal Society.

It consists of two parts: one for determining the time of vibration of a suspended magnet; the other for determining the amount of deflection it produces when caused to act upon a second needle.

In addition there is a third magnet, which is subsequently suspended, and its position referred to the astronomical meridian, by means of a mirror, which serves to allow of an observation of the sun's azimuth being made.

Used by the Rev. S. J. Perry, F.R.S., during the late Transit of Venus Expedition to Kerguelen.

1192. 12-inch Dipping Needle. *Royal Society.*

1192a. 12-inch Variation Needle. *Royal Society.*

1193. Kew Pattern Dip Circle.

Kew Committee of the Royal Society.

Dip circle of the pattern adopted by the Kew Observatory, having needles 3½ ins. long, which are read by microscopes, carried by a circle in front of the needle frame. It is also provided with accessory needles, for determining total force, after the method of Dr. Lloyd.

1196. Portable Theodolite for the observation of the **Magnetism of the Earth,** constructed by Dr. Meyerstein, Göttingen.

Prof. Dr. A. Kundt, Strasburg.

1197. Edelmann's Telescope with graduated Scale, for reading reflecting instruments (small).

M. Th. Edelmann, Munich.

1198. Edelmann's Telescope with graduated Scale, for reading reflecting instruments (large).

M. Th. Edelmann, Munich.

1199. Edelmann's Telescope with graduated Scale, for two observers. *M. Th. Edelmann, Munich.*

1200. Edelmann's Rider, for observing two objects at the same time by means of a telescope with graduated scale.

M. Th. Edelmann, Munich.

1201. Edelmann's Declination Magnetometer.

M. Th. Edelmann, Munich.

1202. Edelmann's Variation Instrument for **Declination.** *M. Th. Edelmann, Munich.*

1203. Edelmann's Variation Instrument for **Horizontal Intensity.** *M. Th. Edelmann, Munich.*

1204. Edelmann's Variation Instrument for **Vertical Intensity.** *M. Th. Edelmann, Munich.*

1205. Edelmann's Magnetometer for declination, vertical and horizontal intensity. *M. Th. Edelmann, Munich.*

1206. Portable Magnet Theodolite.
M. Th. Edelmann, Munich.

1207. Weber's Earth Inductor, new construction.
M. Th. Edelmann, Munich.

1207a. Book, containing special treatises on some of the above instruments. *M. Th. Edelmann.*

1207b. Book, containing the description of the above-named apparatus. *M. Th. Edelmann.*

1209. Photograph of **Gauss's Bifilar Magnetometer.**
Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1210. Photograph of the **observing Telescope,** belonging to the above.
Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1211. Photograph of **Gauss's Earth Inductor.**
Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1212. Photograph of the **Multiplier and Needle.** For the determination of **Inclination** and **Absolute Intensity.**
Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1213. Photograph of the **Auxiliary or Deviation Needle.**
Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1214. Photograph of the **Theodolite** for the determination of the **Declination.**
Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1215. Description of the above-named instruments ; Gauss's Works, vols. 1–7.
Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1216. Dipping Needle with microscopes for the observation of the needle points, constructed by Dr. Meyerstein in 1843.

Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1217. Microscopic Apparatus for the determination of the **Collimation** of **Dipping Needles,** constructed by Dr. Meyerstein in 1843.

Magnetic Department of the Observatory, Göttingen, Prof. Dr. Schering, Director.

1218. Reflecting Dip Circle, after Dr. Meyerstein.

Physical Institute of the University of Göttingen, Prof. Dr. Riecke.

The instrument is so constructed that the magnetisation can be effected either by touching with a steel magnet, or by means of electric coil. In order to carry out the latter, the case is carefully taken off and the coil pushed over pillar and needle.

1219. Model for the illustration of the **Deviation** in **Iron Ships,** after Neumayer, constructed by the Joint-stock Company for the Manufacture of Meteorological Instruments, formerly Greiner and Geissler.

Hydrographical Department of the Imperial Admiralty, Berlin.

This model represents an important apparatus of instruction, which illustrates all the phenomena of deviation and compensation of the compasses. The apparatus is in use in the institutions of the Imperial Navy and schools of navigation.

1220. Gauss's Magnetometer, constructed by Breithaupt and Son, Cassel, with apparatus for suspension.

Polytechnic School in Cassel, Dr. Gerland.

The instrument has been constructed, according to the instructions and under the supervision of Professor *W. Weber* in Goettingen, by Messrs. *Breithaupt and Son.* Since the magnetometer with which *Gauss* and *Weber* had carried out their magnetic labours, and which is identical with the one here exhibited, has not been sent to London, this instrument may be considered as one of the oldest of its kind in the present exhibition.

1221. Photographic self-registering Horizontal Force, or **Bifilar Magnetometer,** constructed in 1847, at the Kew Observatory, by Mr. Francis Ronalds.

Kew Committee of the Royal Society.

Described in the British Association Report for 1849.

The magnet, 15 inches long, is suspended in a loop of fine wire, by means of a pulley, forming a bifilar arrangement. It carries, attached to its lower side, a light brass bar, which moves a little shutter in front of an oil lamp, allowing a pencil of rays to pass through a hole in it. The light is then thrown, by means of a lens, upon a daguerreotype plate, which is steadily drawn upwards by means of a clock.

The curves upon the daguerreotype plates were sometimes etched in, and engravings subsequently worked off, or tracings were made upon sheets of gelatine, which, being preserved, allowed the silvered plates to be repeatedly used.

This instrument was superseded by the improved magnetographs erected at Kew by Mr. Welsh in 1857, which have since remained in almost continuous action.

The suspension frame originally fitted has been replaced by one not belonging to the instrument when in use.

1222. St. Helena Magnetometers.

(1.) Declinometer instrument and telescope, used at St. Helena, 1840–1849.

(2.) Bifilar magnetometer and telescope, used at St. Helena, 1840–1849.

(3.) Vertical force magnetometer, used at St. Helena, 1840–1849. *Kew Committee of the Royal Society.*

The three magnetometers, the declination, horizontal force, and vertical force instruments, respectively, were made by Grubb, of Dublin, and formed one set of those used in the Colonial Magnetic Observatories, founded by the Government in 1840. The instruments were described in the Report of the Royal Society Committee of Physics, &c.

These instruments were erected at St. Helena in 1840, and constantly observed from that date until 1849.

The declinometer consists of a magnet bar, suspended by fibres of untwisted silk, and carrying a collimator arrangement of lens and scale, the whole being enclosed in a cylindrical casing, perforated with windows, through which the scale is viewed by means of a telescope.

The bifilar is a somewhat similar arrangement, but the support of the magnet is formed of two parallel wires, which are twisted so as to bring the magnet into a position at right angles to the meridian.

The vertical force magnetometer is a light magnet 12 inches long, carrying a brass frame with cross wires at each end; it is supported by a steel knife edge, bearing on agate planes, and its movements are observed by microscopes, fitted with micrometers, by which the position of the cross wires on the magnets is read.

1223. Declination Compass, used by Sir J. Richardson and Capt. Pullen.

Kew Committee of the Royal Society.

It consists of a square glazed box, containing a compass card, which is formed of a light metal divided circle, and two spring needles, connected to an agate cap in the centre. This is mounted so that it can either be suspended by a silk thread, or rest upon a point in the ordinary manner.

Two microscopes are fixed vertically above it, so that the divisions on the circle may be read by them, concave metallic reflectors being fitted to them for the purpose of illuminating the scale at the time of reading off.

1224. Portable Apparatus for vibrating a Magnet, used by Capt. Barnett, in H.M.S. "Thunder," in 1841.

Kew Committee of the Royal Society.

It is a glazed box 4 inches square, standing on a levelling stand, and carrying a brass suspension tube 6 inches in length. It also has an ivory circle fixed to its bottom.

There are two magnets 2·7 inches long, each of which when not in use is kept in a separate little copper box, where, fitted to an armature, it is embedded in iron filings.

1225. Dip Circle used by **Sir James C. Ross.**

Kew Committee of the Royal Society.

A Robinson dip circle, with four 6-inch needles, supported on agate planes, and read off direct on the circle of the instrument.

1225a. Apparatus for **discovering the Magnetic Poles** in Magnets and Electro-Magnets, by Professor Th. Petrouchevsky.

Imperial University of St. Petersburg.

A fine metal wire is stretched within the magnetic meridian, above a sensitive marine compass. Within a distance of $0\cdot6^{m}$ from the compass, the pole of which is to be determined, and below the same wire, a magnet is placed, so that its two arms are horizontal, and perpendicular both to the meridian and to the wire. The loaded needle of the compass usually deviates through the effect of the magnet, but in a special case it may be made to remain within the plane of the meridian. To effect this the line passing through the two curved magnet poles must pass also within the plane of the meridian, a thing easily accomplished. In the case of electro-magnets, besides the two bobbins forming part of the electro-magnet, a third bobbin is used, intended to compensate the effect of the first two upon the loaded needle. The description of this method, which presumes that both poles are equidistant from the extremities of the magnet, as also the results of experiments, are published in the Russian work "Cours de Physique Expérimentale," by M. Petrouchevsky, and since in the "Annalen der Physik," by Poggendorf.

1226. Forbes' Hemispheres for illustration of Lectures on the Earth's Magnetism and Temperature.

University of Edinburgh.

1227. Gambey's Declination Compass.

Conservatoire des Arts et Métiers, Paris.

1228. Self-registering Bifilar Magnetometer, with apparatus for determining the temperature-correction of the magnets employed in several automatic instruments, from the displacements of the photographic trace due to observed changes of temperature.

Chas. Brooke, F.R.S.

1229. Self-recording Magnetometer.

Chas. Brooke, F.R.S.

Rough home-made apparatus, by which the first automatic records of magnetic variation by reflected light were obtained. The cylindrical lenses are water-lenses.

1229a. Self-registering Balanced Magnetometer, with compensation for changes of temperature, and warm water envelope for testing the same. The compensation is effected by the weight of the column of mercury in a thermometer tube.

Chas. Brooke, F.R.S.

1229b. Self-registering Barometer.

Chas. Brooke, F.R.S.

1229c. Photographic Apparatus, for registering simultaneously the variations of both the above instruments.

Chas. Brooke, F.R.S.

1229d. Self-registering Bifilar Magnetometer, with compensation for changes of temperature, and warm-water envelope for testing the same. *Chas. Brooke, F.R.S.*

The compensation is effected by diminishing the lower interval of the double suspension, by means of the differential expansion of glass and zinc, in proportion to the diminished magnetic energy of the bar, due to elevation of temperature.

Photographic apparatus for registering the variation of the above, by means of a reflected pencil of light.

1230. Photographic self-registering Declination Magnet, constructed in 1846, at the Kew Observatory, by Mr. Francis Ronalds.

Kew Committee of the Royal Society.

Described in the Philosophical Transactions for 1847, vol. I.

The magnet, 2 feet long, when in use, was suspended by a silken skein, 9 feet long, on its under side; it carries a brass bar, from one end of which hangs a perforated metal plate, which, moving in front of a lamp, permits a pencil of light to fall upon a daguerreotype plate, carried slowly upwards by a clock suitably arranged.

The magnet is surrounded by a damper, made by electrotyping a frame of mahogany with copper. Both are enclosed in double wooden cases, having both surfaces covered with gold paper.

This instrument was superseded by the improved Kew magnetographs, which have been in almost continuous action since 1858.

1231. Instrument for the **determination** of the **position** of the **point** of **convergence** of the rays of the **Aurora Borealis,** both when it is below the horizon and also when it is above the horizon at the appearance of the Corona.

Prof. Heis, Münster.

The ball, resting in the pan, can after a few trials be brought into such position that several diverging pencils of the aurora borealis on the northern or the southern sky are, when properly viewed, covered by the rod which passes through the centre of the ball. The point of this rod, which can be moved up and down in the ball, shows, when the instrument is set according to the astronomical meridian, the azimuth and altitude of the converging point of the aurora pencils. This point of convergence does not exactly coincide, as the exhibitor has shown at the time of the great display of aurora borealis, Feb. 4th, 1872, with the point towards which the inclination needle directs. From the deviation of the two points, the height of the aurora can be calculated.

The instrument, which is easily manipulated, is much recommended to arctic explorers.

Instrument for navigators in the Arctic Regions for ascertaining the connexion of the Northern Lights with terrestrial magnetism, and for determining the altitude of the Northern Lights. By means of an instrument designed by the exhibitor, the point of convergence of the north light rays is to be accurately determined, as well when at the appearance of the corona it is situated above the horizon, as when it is below the same, and in regard to altitude and azimuth. By the deviation of the point of convergence from the direction of the dipping needle, the height of the north light rays can be calculated.

1231b. Compass with **Diamond Pin.**

Ernst Winter, Hamburg, Eimstustel.

SECTION 10.—ELECTRICITY.

West Gallery, Ground Floor, Room F.

I.—APPARATUS FOR PRODUCING AND MAINTAINING DIFFERENCES OF ELECTRICAL POTENTIAL.

a. Friction and Induction Machines.

1233. Electrical Machine, having ebonite plate 3 feet in diameter. *Frederick Guthrie.*

This machine gives sparks 13 inches long.

1233a. Priestley's Electrical Machine. *Royal Society.*

1267. Winter's Machine, with 18-inch ebonite plate and condenser attached, for the accumulation of electricity. *Elliott Brothers.*

Large Double-Plate Vulcanite Friction Electric Machine. *Dr. W. H. Stone.*

1233a. Large Electrophorus, with ebonite plate, 360mm. diameter. *Warmbrunn, Quilitz, & Co., Berlin.*

1234. Carré's Electric Machine. *Prof. W. F. Barrett.*

This is an induction machine or continuous electrophorus, but the loss from the inductor is replaced by a small attached frictional machine.

1234a. Froment's Electric Pendulum. *Prof. W. F. Barrett.*

The pendulum is kept in motion by a current passing round the electro-magnet which lifts a small weight that is released as the pendulum descends. A control clock is in connexion with the pendulum.

1234b. Crystal of Tourmaline, mounted to show Pyro-Electricity. *Prof. W. F. Barrett.*

This crystal during heating or cooling exhibits polarity at its extremities. It is pivoted on a diamond cap.

1234c. Electrical Machine, by Singer, used by Mr. Francis Ronalds in his early experiments in the discovery of the electric telegraph; described in his work on the electric telegraph, dated 1823. *Kew Committee of the Royal Society.*

It is an ordinary cylinder machine of blue glass, standing on glass columns.

1235. Bertsch's Machine. *Frederick Guthrie.*

A negatively excited sheet of ebonite leans against a revolving disc of the same material. On the other side of the revolving disc, one above and one below, are electric rakes. The conductor in connexion with the lower rake becomes negatively charged, the other one positively.

1236. Holtz's Machine. *Frederick Guthrie.*

A good example of this machine in one of its original forms, with windows and armatures. It gives a current of sparks over an interval of 8 inches.

1237. Electrical Machine, based on Holtz's principle, with ebonite discs. *Dr. L. Bleekrode, The Hague, Holland.*

This machine is constructed for generating electricity on the principles of induction as first employed by Holtz. The form is very much simplified, and the only material used is ebonite (india-rubber combined with sulphur). Two forms are constructed by the exhibitor; the single ebonite machine with one fixed disc and another rotating before it, and the double ebonite machine. The latter consists of one fixed disc with paper armatures placed in the ordinary way but on both sides, a double system of conductors, and two rotating discs. The construction is no more complicated than that of the single machine, yet the quantity of electricity is exactly doubled.

The advantages of the machines constructed in this way, supported by experience of more than two years, may thus be briefly stated :—

(1.) The ebonite machines, constructed on the system of the exhibitor, with ebonite of a good quality (which may be easily had but must be carefully chosen) are at least as powerful in their action as the machines with glass discs, but they surpass them in being less costly, not liable to be broken, and much less dependent on the condition of the atmosphere. This must be appreciated in England, where, as is the case in Holland, glass electrical machines (working by induction) often remain inoperative owing to atmospheric moisture.

(2.) Although of very simple construction, they are very useful and powerful machines.

(3.) From a theoretical point of view they present many interesting properties when compared with machines in which glass is employed, and this led to the conclusion that they differ in their mode of producing electricity. An experimental investigation of this machine, stating its peculiarities, has been published in Poggendorff's Annalen, 1875, No. 10, pp. 278, 279.

1241. Di-Electrical Machine. *M. Carré.*

4560. Photograph of the "Cecchi Electrical Machine," formed of two discs, which are placed partially one over the other, the one of caoutchouc, and the other of glass, with parallel axes. *Prof. Filippo Cecchi, Florence.*

The Cecchi electrical or dielectrical machine is composed of two discs with parallel axes. The upper disc is of india-rubber, and is supported by an axis of glass ; the one below is of glass on an axis of metal. The axis of the glass disc has on one side a large pulley, and the axis of the other disc a small pulley, and by means of a continuous cord, not crossed, there is transmitted to the caoutchouc disc a rotatory motion eight or ten times faster than that of the glass-disc ; both the discs turn in the same direction. The discs are partially placed one above another, and are very close but without touching. The upper part of the caoutchouc disc passes between two arms furnished with metallic points, and connected with a large sphere of brass insulated at the extremity of a long glass rod. To this sphere is attached the hook of a condenser or else a Leyden jar formed by a barometer-tube with very thick walls. The lower part of the same disc passes before a comb of metallic points, called a T-comb, which communicates with the external armature of the condenser, and with two friction cushions of the glass disc, and then with the ground, and also with an exciter formed by a tube of brass with a ball at the end. When the discs are revolving, the large sphere becomes charged with negative electricity. This machine with discs of 80 centimètres diameter has given sparks of the length of 42 centimètres free in the air.

1242. Holtz's Machine, with four plates. *M. Ruhmkorff.*

1242a. New form of Holtz's Machine.
Francis Pizzorno, Bologna, Italy.

This machine has the property of working well whatever may be the hygrometric condition of the air, since the two glass plates are placed in a crystal case hermetically closed. The air of the case is maintained continually dry by means of drying substances.

The conductors issue from the case and unite at the two Leyden jars which appear on the front of the figure.

1242b. Fixed Disc for a Holtz's Machine.
Augustus Righi, Professor of Natural Philosophy, Bologna.

The greatest possible difference of potential between the conductors of a Holtz's machine depends on the difference of the potentials of the paper surfaces carried by the fixed disc. But this latter difference is limited by the discharges which continually occur along the fixed disc. An ebonite plate is joined perpendicularly on the fixed disc, separating it into two parts, so that the discharges must follow the two faces of the plate. The potentials of the paper surfaces are increased, and the sparks between the conductors become longer.

This machine possesses four rows of points, namely, the two rows of points of the conductors, and the two rows of points obliquely communicating.

1242c. Large Electrical Machine, with double ebonite plates and Waiter's ring, formerly the property of Lord Lindsay.
Dr. Stone.

1268. Replenisher. Designed by Sir W. Thomson for restoring electricity to the Leyden jar of his quadrant electrometer.
Elliott Brothers.

A small charge being given to the Leyden jar, the replenisher increases or decreases the difference of potentials between the two coatings of the jar by a constant per-centage per half turn.

1243. Old Electrical Machine, with glass cylinders, one of which is covered with sealing wax, so as to obtain both positive and negative electricity.
The Council of King's College, London.

1244. Nairne's Early Electrical Machine, with glass globe. *The Council of King's College, London.*

1245. Cylinder Electrical Machine.
The Council of King's College, London.

1246. Plate Electrical Machine, with four rubbers.
The Council of King's College, London.

1247. Armstrong's Electric Boiler or **Hydro-Electric Machine.** *The Council of King's College, London.*

1248. Volta's Electric Lamp, or apparatus for lighting gas by means of an electric spark.
The Council of King's College, London.

It contains a leaden bottle for the generation of hydrogen gas. In the orifice are two wires separated from each other, which are connected to the two plates of an electrophorus. One of the wires is connected with the tap, so that the upper plate of the electrophorus is raised at the same time that the hydrogen is allowed to escape at the orifice, and the spark from the electrophorus sets fire to the hydrogen and thus lights the lamp.

1729. Glass Globes for producing Electricity by rubbing with the hand. *The Council of King's College, London.*

The globes are caused to revolve by means of multiplying wheels and a band of rope. The globes may be exhausted, and they then become luminous; the greatest amount of electricity or "fire" was obtained from them when they were exhausted. In the one with a large brass cap, a small wooden disc could be inserted with threads distributed round its edge; when the globe was excited the threads stood out from the edge of the disc. Constructed about A.D. 1720.

1249. Induction Electric Machine. *T. Rob. Voss, Berlin.*

As there is no glass in Germany which insulates perfectly, Professor Helmholtz has used Leyden jars made of ebonite or vulcanite, which can keep electric charges for 14 days, or 14 times longer than the glass jars of Kirchhoff.

The advantages of this instrument are:—(1.) That the quadrants with the needle and mirror can be easily removed, so that any change in the needle or misplacement of the mirror may be examined with certainty.

There are new arrangements in the Leyden jar for raising or turning the needle without shaking the entire instrument (a thing to be avoided).

1249b. Combined Holtz's and Bertch's Induction Machine, with arrangement for separating the same.
Harvey, Reynolds, and Co.

1249c. Induction Electric Machine. *J. Teller, München.*

The fixed disc has neither holes nor cuts, which were hitherto considered indispensable.

1249d. Toepler's Induction Machine.
Royal Institution of Great Britain.

The apertures usual in the fixed disc are here dispensed with as unnecessary, the disc is thus rendered less breakable, and a greater action is obtained. The apparatus is very simple in construction and can easily be taken asunder for cleaning. The driving disc is at the same time utilised as the exciter of electricity.

1250. Holtz's Electric Machine, with fixed induction surface. *Borchardt, Hanover.*

1251. Holtz's Electric Machine, with movable induction surfaces. *Borchardt, Hanover.*

1542d. Electric Machine, with large ebonite disc.
C. Etler.

1252. Machine for **exciting Positive** and **Negative Electricity.** *E. Stöhrer, Leipzig.*

It has the form of a small disc electric machine. According as one or other brass ball at the end of the caoutchouc frame is taken hold of, a quantity of positive or negative electricity is obtained.

b. GALVANIC BATTERIES.

1285a. Apparatus for Volta's Fundamental Experiment, with arrangement for chloride of calcium, two brass, one copper, one zinc plate, and insulating handle.
Warmbrunn, Quilitz, & Co., Berlin.

1253. Water Battery.
The Council of King's College, London.

1254. Daniell's Battery, employed in researches by Professor Daniell. *The Council of King's College, London.*

1255. Early Voltaic Batteries:—
Babington's battery.
Cruikshank's „
Wollaston's „
Sturgeon's „
The Council of King's College, London.

1256. Hare's Calorimotor, or Deflagrator.
The Council of King's College, London.

1257. De La Rue's Powder Chloride of Silver Battery.
Tisley and Spiller.

1257a. Forty Cells of a Rod Chloride of Silver Battery, being part of a battery of 8,040 cells.

Warren De La Rue, F.R.S., and Hugo W. Müller, F.R.S.

The elements consist of a flattened silver wire and a zinc (non-amalgamated) rod. The electrolytes are a solution of chloride of ammonium, 23 grammes to a litre of water, and fused chloride of silver cast on to the silver wire.

When the terminals are not connected, the battery is quite inactive; one such battery has been in action since November 1874. In order to prevent contact between the chloride of silver and the zinc rod, the rod of chloride of silver is encased in a tube of vegetable parchment open at both ends. The cell is a glass tube closed with a paraffin stopper.

Such a battery will evolve three cubic centimetres of mixed gases per minute, if connected up with a voltameter containing one volume of sulphuric acid, and eight volumes of water.

This battery is particularly well suited to experiments with a large number of elements, on account of its constancy.

8040 cells give a spark in air between a point (positive) and a plate (negative) of 0·342 inch (8·68 mm.); the striking distance (*distance explosive*) is shorter when the point is negative and the length of the spark is materially affected by slight differences in the form of the point; the point used is parabolic in form and is made of copper wire 0·125 inch (3·175 mm.) in diameter, the plate 1·1 inch (27·94 mm.) in diameter. The length of the spark between a point and a plate appears to be in excess of the ratio of the square of the number of cells; for example 8,000 will give a spark 64 times as long as the spark from 1,000 cells. Between two spherical surfaces of 3 inches (76·2 mm.) radius and 1·5 inch (38·1 mm.) in diameter; the striking distance (*distance explosive*) is only 0·038 inch (2·1 mm.); between spherical surfaces the law of the striking distance being in the ratio of the square of the number of cells does not hold. When a resistance is introduced into the circuit of 6,000,000 Brit. Ass. units (ohms), a series of intermittent brilliant sparks is obtained like those from an electrical machine; but without resistance when the spark jumps the ordinary voltaic arc is formed. The current of 8,040 cells passes through a residual hydrogen vacuum of 38 mm. tension in a tube 1·6 inch (40·6 mm.) diameter, and 27 inches (58·58 centimeters) between the terminals; the current of 1,200 cells passes with a tension of 0·2 mm.

1258. Portable Medical Battery, with modified form of De La Rue's chloride of silver and zinc elements.

Tisley and Spiller.

1259. New Galvanic Battery for Domestic Purposes.

Aurel de Ratti.

This Zinc-Carbon Battery is charged with a saturated solution of sulphate of magnesia or Epsom salts, a very cheap material. The flask above the cell is filled with crystals of this salt, on which a saturated solution of the same is poured until the flask is quite full. The cork with the glass tube is then forced down till the solution rises and fills the tube. A small cork is loosely fixed in the open end of the glass tube. No air must be allowed to remain in the tube or flask. The latter is now inverted, and the tube introduced through the round hole in the lid. The flask will be held in position by the projecting cork fitting into the round hole. The end of the glass tube will thus be immersed in the solution in the jar. The carbon-plate is finally pushed through the square aperture in the lid, and by a simple manipulation the cork is pushed from the open end of the glass tube.

1259a. Muirhead's new Manganese Battery.

Warden, Muirhead, and Clark.

The positive plate is of zinc of a hollow cylindrical form placed in a perforated vitreous chamber. The negative plate is of platinized carbon, surrounded with lumps of platinized carbon and di-oxide of manganese. The exciting liquid is a solution of muriate of ammonia. Its electro-motive force is 1·6 volts, internal resistance, 2 ohms. Electro-motive force of a Daniell cell, 1·1 volts.

1260. Gas Voltaic Battery devised by W. R. Grove, Esq., M.A., F.R.S., Professor of Experimental Philosophy in the London Institution (now The Hon. Sir W. R. Grove), and described by him in a communication read before the Royal Society, May 11th, 1843. Experiments with this battery are described in a postscript, dated July 7th (Phil. Trans., 1843, p. 91).

London Institution, Finsbury Circus, E.C.

It consists of a series of Woulfe's bottles, into the necks of which glass tubes closed at one end are fitted by grinding; each tube contains a slip of platinum foil, coated with finely divided platinum, the slip being connected with a wire sealed into the end of the tube, and terminating outside in a little cup; the cups being filled with mercury, the tubes may be connected by wires dipping into the mercury. When the Woulfe's bottle and its tubes are filled with dilute sulphuric acid, and one of the tubes is then charged with hydrogen and the other with oxygen, in quantities such as will allow the platinum to touch the acid, and the ends of a wire are dipped into the cups at the tops of the tubes, an electric current is produced. At the same time the gases in the tubes gradually diminish in volume, the volume of hydrogen which disappears being double that of the oxygen; the current being generated, in fact, by the formation of water.

1260a. The Original Nitric Acid Battery.

The Hon. Sir W. R. Grove, F.R.S.

1261. Grove's Gas Battery, made by Spencer and Son, Dublin. *Prof. W. F. Barrett.*

The current in this battery is produced by the gradual union of the gases oxygen and hydrogen, which fill the alternate upright glass tubes. Strips of platinum passing down the tubes serve for making metallic connexion with the gases.

1262. Constant Gas Voltaic Battery devised by W. R. Grove, Esq., M.A., F.R.S., Professor of Experimental Philosophy in the London Institution (now The Hon. Sir W. R. Grove), and described by him in a communication to the Royal Society, dated May 30th, 1845. *London Institution, Finsbury Circus, E.C.*

To charge the apparatus, the stopper is removed from the end of the tube, and the glasses are filled to the top of the narrow platinum plates with acidulated water; acid is also poured into the end vessel, so as to cover the lump of zinc. The hydrogen which is evolved by the action of the zinc on the acid gradually expels the air from the main channel, and, when this is judged to be the case, the stopper is inserted; the hydrogen will now rapidly descend in all the tubes until the zinc is laid bare, and then remain stationary. A gas battery is now obtained, the terminal wires of which will give the usual voltaic effects, the atmospheric air supplying an inexhaustible source of oxygen, and the hydrogen being renewed as required by the liquid rising to touch the zinc; by supplying a fresh piece of zinc when necessary it becomes a self-charging battery, which will give a continuous current; no new plates are ever needed; the electrolyte is never saturated, and requires no renewal except the trifling loss from evaporation, which indeed is lessened, if the battery be in action, by the newly composed water.

1263. Element of M. Becquerel's Sulphate of Copper Battery. *Conservatoire des Arts et Métiers, Paris.*

1264. Twelve Elements of Galvanic Batteries on different systems, by Ruhmkorff. *Conservatoire des Arts et Métiers, Paris.*

1266. Smee's Battery. Six cells, with arrangement for raising the plates out of the cells. *James How & Co.*

1266a. Set of Six Cell Smee's Batteries.
E. Cetti and Co.

1269. Grove's Nitric Acid Battery. *Elliott Brothers.*

1270. Faure's Nitric Acid Battery. *Elliott Brothers.*

The advantages offered in this battery are, greater constancy; less inconvenience from fumes, the porous cell being a stoppered bottle; and it not being necessary to amalgamate the zincs, common salt being used in the outer cell.

1271. Glass Battery Cell, with two carbon and two zinc plates. *Keiser and Schmidt, Berlin.*

1272. Glass Battery Cell, with two carbon and one zinc plate. *Keiser and Schmidt, Berlin.*

1273. Glass Battery Cell, with one carbon and one zinc plate. *Keiser and Schmidt, Berlin.*

1274. Dipping-Battery, with 10 elements, of the exhibitors' own construction. *Keiser and Schmidt, Berlin.*

1275. Dipping-Battery, with 16 elements, with pachytrope of the exhibitors' own construction. *Keiser and Schmidt, Berlin.*

1276. Battery for Field Telegraph Service, constructed for the Prussian Railway Battalion according to the plan of Captain Witte. *Keiser and Schmidt, Berlin.*

1277. Leclanché Cell, for working house telegraphs, modified by the makers. *Keiser and Schmidt, Berlin.*

1277a. Yeates' Improved Leclanché Cell.
Prof. W. F. Barrett.

New form of Leclanché cell, the position of the zinc and carbon are reversed, thus rendering it less liable to polarisation, and hence far more constant than the ordinary form. Made by H. Yeates, King Street, Covent Garden.

1278. Drawing and **Description** of a **Galvanic Battery,** with arrangement for combining the elements ad libitum.
Dr. Tasché, Giessen.

1279. Portable Battery for **Electro-therapeutic Purposes.** 24 elements. *Prof. Beetz, Munich.*

1279a. Round Immersion Battery, with automatic break for medical purposes. *J. Teller, München.*

By this arrangement powerful action is obtained, and a very constant current, even with great resistance. The consumption of zinc is (in consequence of self-amalgamation in the acid chromate of mercury solution) very small, and this result is also favoured by the small immersion, which is limited by the slide on the upright bars. By the automatic interrupter, the battery can be used also with intermittent current, and such a battery current (because without alteration of poles) is to be preferred to the action of an induction current.

1280. Portable Battery, with **Ebonite Insulations** for the investigation of tension phenomena. 16 cells.
Prof. Beetz, Munich.

1281. Delicate Battery, with four platinum-zinc elements, two silk conducting strings, with eight reserve plates in a case.
Kgl. Chirurgische Klinik, Breslau, Prof. Dr. Fischer.

1282. Delicate Battery, with four carbon-zinc elements.
Kgl. Chirurgische Klinik, Breslau, Prof. Dr. Fischer.

1283. Delicate Battery, with two carbon-zinc elements, two conducting strings, and three reserve plates in case.
Kgl. Chirurgische Klinik, Breslau, Prof. Dr. Fischer.

1284. Small Battery, with two platinum-zinc elements.
Kgl. Chirurgische Klinik, Breslau, Prof. Dr. Fischer.

In galvanocaustics (the art of destroying diseased portions of tissue by means of the electric current) the batteries used generally consist of four very large Grove or Bunsen elements. Wires proceed from the battery to a piece of platinum, which is to be raised to a red heat. This collection shows Middeldorff's original arrangement, as used in Breslau, and also recent modifications.

Two Secondary Elements, by Planté.
M. Bréguet, Paris.

Battery of 20 Secondary Elements, by Planté.
M. Bréguet, Paris.

Battery of 20 Secondary Elements, by Planté.
M. Bréguet, Paris.

c. THERMO-ELECTRIC BATTERIES.

Thermo-electrical Pile of Nobili, composed of 12 elements disposed in rays.
The Royal Institute of "Studii Superiori" at Florence.

Thermo-electrical Pile of Nobili, divided into three small ones of 12 elements each, to be combined at will.
The Royal Institute of "Studii Superiori" at Florence.

53. Thermo-electrical Pile of Nobili for the experiments on radiant heat, composed of 37 elements, and furnished with a conical mirror.
The Royal Institute of "Studii Superiori" at Florence.

It is well known that Leopoldo Nobili, who was for several years professor at the Royal Museum of Physical Science and Natural History of Florence, was famous for the construction of thermo-electrical piles, of which he made much use in his important experiments on radiant heat, partly carried out in conjunction with the celebrated Melloni.

1298a. Nobili's First Thermo-Electric Battery.
Prof. Dove, Berlin.

1298b. Melloni's First Thermo-Electric Pile.
Prof. Dove, Berlin.

1298c. Antinori's First Apparatus for Induction Sparks. *Prof. Dove, Berlin.*

This apparatus was bought at an auction in Florence, after Nobili's decease.

1286b. Thermo-Electric Apparatus by Seebeck.

1. Ring of copper and antimony.
2. Cylinder of copper and antimony, 46 mm. in diameter and 22 cm. in length.
3. Six circular discs ; diameter 10 cm. ; of copper, brass, and other alloys.
4. Square disc, 16 cm.
5. Two rods, Bi. Sb.

Prof. Dr. Dove, Berlin.

(Property of the Royal Academy of Sciences at Berlin.)

1265. Pouillet's Thermo-Electric Battery.
Conservatoire des Arts et Métiers, Paris.

1285. Thermo-electrical Battery, bismuth and antimony.
Geneva Association for the Construction of Scientific Instruments.

1286. Nobili's Thermo-Electric Pile, of 54 pairs of bismuth and antimony bars, soldered alternately together; the smallest difference of temperature between the two faces of the pile develops a current, readily indicated by a suitable galvanometer.
Elliott Brothers.

1235c. Apparatus intended for producing **Thermo-electric Currents** in a special manner.
Imperial University of St. Petersburg.

It consists of ten straight electro-magnets, with their poles joined alternately so as to form a zig-zag. The iron cores are not in direct contact but are connected by small brass cylinders to which they are soldered at their extremities. These small cylinders carry brass plates and rods placed alternately. When the apparatus is to be used, these plates are heated approximately up to 100° centigrade; the brass rods are cooled with crushed ice, and then the galvanic current of a six element battery (carbon, zinc, chromic liquid,) is passed through the bobbins of the electro-magnets, odd or even numbers. The thermo-electric current produced by the iron cores produces a strong deviation of the needle of a sensitive galvanometer of small resistance.

The fact of the heterogeneousness of magnetised metals and non-magnetise metals was discovered by Sir W. Thomson. The apparatus here described is constructed by Prof. T. Petrouchevsky, Professor at the University of St. Petersburg. The first experiments made with this apparatus, slightly altered however, have been briefly described in Russian in the "Journal of the Russian "Society of Chemistry," and in that of "The Physical Society of the University of St. Petersburg," Vol. 6, Section Phys., p. 107 (1874).

1287. Noë's Thermo-electric Battery of 96 pairs. Convenient for lecture experiments. *George Gore, F.R.S.*

Attains its maximum power in about one minute. May be heated to low redness. Decomposes water freely. Will excite an electro-magnet to sustain 2 cwt. It has an arrangement, or "current transformer," by means of which its entire power can be employed with three different combinations of its elements, viz., as 96 by 1, 48 by 2, or 24 by 4, and changed instantly from one combination to another. The connexions of the "transformer" require no cleaning. Made by W. J. Hauck, Vienna.

1288. Small Single-cell Apparatus, with platinum-plates, for showing the thermo-electric properties of liquids.
George Gore, F.R.S.

(*See* Philosophical Magazine, Jan. 1857.)

1289. Single-cell Apparatus, for examining the thermo-electric properties of liquids. *George Gore, F.R.S.*

(*See* Proceedings of the Royal Society, 1871.)

1290. Large Single-cell Apparatus, with platinum-plates, for showing the thermo-electric properties of liquids.
George Gore, F.R.S.

1291. Four-cell Apparatus, with copper plates, for showing the thermo-electric properties of liquids. *George Gore, F.R.S.*

(*See* Philosophical Magazine, 1857.)

1292. Twelve-cell Apparatus, with platinum-wire electrodes, for examining the thermo-electric properties of liquids. *George Gore, F.R.S.*

(*See* Proceedings of the Royal Society, 1871.)

1293. Model of the most improved form of apparatus for investigating the thermo-electric properties of liquids. Used with ribbons of platinum, gold, palladium, and silver. *George Gore, F.R.S.*

1297. Thermo-Battery. *Siemens and Halske, Berlin.*

1297a. Thermo-Electric Pile, small student's form, nickel-plated. *Harvey, Reynolds, and Co.*

1298. Thermo-Electric Pile (Noë's system), with 64 elements, heated by gas. The electro-motive power equal to six Bunsen elements. *P. Dörffel, Berlin.*

The elements, consisting of a round rod (positive) and thin wires (negative), are arranged in two opposite rows of 64 elements each, whose heating bars (cast of positive metal and protected against the flame by copper casing) project in a row into the open space between the elements, so that they are all alike heated by the stand of Bunsen burners below, and convey the currents to the elements. The cooling of the other junctions is effected by means of metallic cooling-plates attached to them, supported by the wooden frame under the elements. The electro-motive force is equal to 6 Bunsen or 120 Jacobi-Siemens' units. The resistance = 2·45 Siemens' units. The pile contains a Dove's Pachytrope, in order to arrange the elements in groups of 1, 2, or 4, by means of which the resistances and the electro-motive force may be changed.

1299. Thermo-pile (Noë's system), with 20 elements in radiating arrangement, heated by gas. The electro-motive power is equal to one Bunsen element. *P. Dörffel, Berlin.*

Here the elements are arranged radially, so that the heating bars all run to a middle point, where they can be heated by the single flame of a Bunsen burner. The cooling is done with metal plates which are rolled into a tubular form, and serve at the same time as stands for the battery. The electro-motive force is equal to 1 Bunsen or 20 Jacobi-Siemens units. This apparatus (as also the next, 1300) is recommended for small experiments in electrolysis, &c.

1300. Thermo-electric Pile (Noë's system), heated by a spirit lamp, with 20 smaller elements, and consequently of greater resistance. The electro-motive power is equal to one Bunsen element. Resistance equal to 0·52 Siemens' units. *P. Dörffel, Berlin.*

1301. Thermo-electric Pile (Noë's system), heated by a spirit lamp, with 10 smaller elements. Its electro-motive power is equal to 0·5 Bunsen element. *P. Dörffel, Berlin.*

Designed specially for medical use, in connexion with a small induction apparatus. Should long action be desired it is well to place the battery with lamp in a vessel with water, to avoid the great heating its small size involves, and to increase the action.

1294. Thermo-Electric Battery or Clamond Pile. *Thermo-Electric Company.*

The poles or generators are constructed of zinc and antimony, both being metals bearing great electrical properties. The electricity is given out without any intermediate agency, except heat, which is generated as gas; coke or charcoal is consumed. Economy in maintenance, and cleanliness in application, gives this arrangement an advantage over other batteries, and the current obtained is constant and free from polarisation or exhaustion.

1301a. Thermo-Electric Generator (Clamond's Patent). Constructed either for electrotyping, plating, gilding, or telegraphy. A pile of 100 bars, with a gas jet burning 4 feet per hour, will deposit an ounce of copper per hour.
Thermo-Electric Generator Company (Clamond's Patent).

The Thermo-Electric Piles or Generators are constructed of elements, one pole of which is tinned iron, the other being an alloy of two parts of antimony to one of zinc. The iron is cast into the alloy, and thus a perfect connexion is made. The pairs thus formed are then laid side by side, and being cemented together, form a ring or crown (the cement used is a mixture of asbestos and silicate of soda); one crown being complete another is laid above it, though insulated from it by the same cement, and so on, giving the pile a cylindrical form. The junctions are heated thus: Up the centre of the pile is placed a perforated earthen tube and gas issuing from a Bunsen's jet burns at the perforations, heating an iron core red hot, which radiates its heat to the junctions of the pairs, thus the flame never impinges on the metals, and all oxidization, &c. is obviated; the heated air passes over the top of the iron core, and curling down, escapes by a pipe from the bottom of the pile. The elements of each crown are connected in series, but the terminals of every crown are brought into a wooden support and can be connected at will for high tension or great quantity. As a standard of power the following may be used:—

A 100 bar pile consuming 4 feet of gas per hour has E.M.F. 5 volts., Int. Res. 1 ohm.

A 240 small tension bar pile, consuming 4 feet of gas per hour has E.M.F. 12 volts., Int. Res. 6 ohm.

Piles are also made to be heated by coke or charcoal, and a battery having an E.M.F. of 20 volts, and Int. Res. of 4 ohms burns 2 lbs. of coke per hour. Petroleum is also used for heating the piles.

1301b. Thermo-Electric Pile of Hydrogenium. *Prof. Dewar.*

Consists of alternate layers of Palladium and Hydrogenium; electromotive force equal to that of iron and copper.

1096. Thermo-electric Diagram for teaching purposes. (Trans. Roy. Soc. Edin., 1872–3.) *Prof. Tait.*

d. INDUCTION COILS.

1303. Ruhmkorff's Coil. *Frederick Guthrie.*

The current from a galvanic battery passing through a spiral of copper wire magnetises the soft iron bars placed within it, which by their attraction so move a steel spring as to interrupt the current. The current being thus broken, the magnetisation ceases until the current is again restored. The result is a very rapid making and breaking of the current in the spiral or primary wire. Outside the primary are many miles of fine insulated copper wire called the secondary wire. Connected with the primary by wires, one on each side of the contact breaker, is a tin-foil condenser. This absorbs the extra-current when the primary is broken, and serves to augment the secondary when the primary is made. The interior magnetism acts in the same direction.

1304. Six-inch Induction Coil, and Browning's Spark Condenser, for obtaining spectra of metals by the induction spark. *John Browning.*

When using the spark condenser the amount of coated surface introduced may be varied at pleasure, and the density of the spark thus regulated.

1304a. Apps' Patent Induction Coil, giving sparks of 17 in. in air, with a battery of five Grove's cells, platinum, 5 × 3 in. immersed. *Alfred Apps.*

1304b. Henry's Induction Coils.
The Council of King's College, London.

1304aa. Large Induction Coil, with thick secondary wire (10½ miles in length), and improved form of contact-breaker by which a long interval of contact is obtained. *Horatio Yeates.*

This is wound on the plan proposed by Dr. Fergusson (in two divisions), the secondary wire which is No. 32, B. W. G. is 10½ miles long. The primary wire, No. 8, B. W. G. is wound in two laps.

The condenser is composed of 70 sheets of tinfoil, 26 × 16, insulated with paraffine paper.

The contact-breaker, which is so formed as to give a long interval of contact, is also furnished with an adjustment by means of which the coil can be worked with a very small battery, and maximum results obtained with the largest suitable battery.

1305. Large Induction Coil, with Foucault's break; will give 18-inch sparks. A cube of glass which was pierced by this coil. *M. Ruhmkorff.*

1305a. Electric Necessaire, containing Ruhmkorff bobbins.
M. Loiseau, jun., Paris.

1306. Induction Apparatus for medical purposes.
Keiser and Schmidt, Berlin.

1307. Induction Apparatus for medical purposes.
Keiser and Schmidt, Berlin.

1308. Induction Apparatus for medical use.
Keiser and Schmidt, Berlin.

1309. Spark Induction Machine, No. 1, with armature and Geissler's tubes. *Keiser and Schmidt, Berlin.*

1310. Spark Induction Machine, No. 2, with armature and Geissler's tubes. *Keiser and Schmidt, Berlin.*

1311. Spark Induction Machine, length of spark, six millimeters. *Keiser and Schmidt, Berlin.*

1312. Spark Induction Apparatus, length of spark, one centimeter. *Keiser and Schmidt, Berlin.*

1313. Spark Induction Apparatus, length of spark, 4·5 centimeters. *Keiser and Schmidt, Berlin.*

1314. Spark Induction Apparatus, length of spark, 8 centimeters. *Keiser and Schmidt, Berlin.*

1315a. Great Induction Coil.

66 Leyden jars and fittings.
6 stands for jars.
The Royal Polytechnic Institution.

c. MAGNETO-ELECTRIC MACHINES.

1303a. First Induction Machine, called **"de Pixii,"** constructed under the direction of Ampère.
College of France, Paris.

1686. Galvanometer of Nobili.
The Royal Institute of "Studii Superiori" at Florence.

Rose of Metallic Colours obtained by means of electricity by Leopoldo Nobili.
The Royal Institute of "Studii Superiori" at Florence.

A very great number of liquids and metals were subjected by Nobili to experiments in order to obtain, by means of electricity, the coloured rings which bear his name; and exceedingly important are his observations on the complete scale of colours which he succeeded in forming and which yet exist at Florence.

1687. Original Magneto-electrical Machine of Leopoldo Nobili and **Vincenzo Antinori,** which gave, on the 30th of January 1832, the first spark, before Leopold II.
The Royal Institute of "Studii Superiori" at Florence.

This is the first machine with which the induction spark was obtained by means of an artificial magnet. The anchor (*ancora*) tied by a thread, and movable like a lever round a pivot, is detached from the loadstone by a blow, while at the same time, by means of a spring, the electrical circuit is interrupted, so that the spark appears at the point of interruption. Faraday, who was the first to observe the induction currents, obtained the spark by using an electro-magnet; the arrangements, however, of Nobili and Antinori were the first that constituted a true magneto-electrical machine. And we may also remark that, at the same time, Nobili and Antinori obtained the electric spark, likewise, by means of the natural magnet of the museum, an enormous parallelopiped of about 50 × 65 × 78 centimeters in dimension.

1114. Saxton's Magneto-Electric Machine. Copy of the original machine made by Mr. Saxton, and exhibited by him before the third meeting of the British Association, held at Cambridge in the year 1833. *John O. N. Rutter.*

This machine was made specially for the contributor by Mr. Saxton, immediately after the meeting at Cambridge, and has been in his possession ever since. It is capable of producing sparks, shocks (through the tongue), and decomposes water. It also reproduces the ordinary phenomena of electro-magnetism.

The machine is described in Daniell's "Introduction to Chemical Philosophy," 1843, p. 585, sec. 873.

1316. Ladd's Dynamo-Magneto-Electric Machine.
William Ladd & Co.

Invented March 1867. (*See* Proceedings of the Royal Society, No. 91, 1867.)

This was the first machine with two armatures, one being employed to excite the electro-magnets and the other to produce an electric current, which may be used for any purpose to which a battery is applicable.

1316a. Ladd's Dynamo-Magneto-Electric Machine, with two wires on one armature. This machine will heat 15 inches of platinum wire. *William Ladd & Co.*

1317. The first Magneto-Electric Machine, with circular magnets, 1866. *William Ladd & Co.*

1318. Magneto-Electric Machine, with circular magnets, larger form, 1867. *William Ladd & Co.*

1319. Magneto-Electric Machine (direct current).
James How & Co.

1320. Magneto-Electric Machine (Duchenne's form).
James How & Co.

1321. Magneto-Electric Machine (Clark's form). An early machine by Logemann, of Haarlem. *James How & Co.*

1322. Electro-Magnetic Coil Machine, for medical application. Primary and secondary currents. *James How & Co.*

1323. Magneto-Electric Machine, with alternate current for production of light. *La Société l'Alliance.*

A magneto-electric machine, with four discs or 64 bobbins with alternate current for the production of light. This machine requires a driving power of 3 H.P. when revolving from 400–450 times per minute.

1324. Magneto-Electric Machine, to be worked by hand or steam. *La Société l'Alliance.*

This machine with eight bobbins is for the purpose of demonstration with direct and alternate current, and can be worked by hand or steam.

1325. Experimental Magneto-Electric Machine, the first constructed in which electricity and magnetism, rendered active by the expenditure of mechanical force, were made to act and re-act on one another in such a way as to greatly increase the development of their forces. *S. Alfred Varley.*

This machine was the first of its class, and acted on what was a new principle at the date of its construction. The new principle consisted in making electricity and magnetism, rendered active by the expenditure of mechanical force, act and re-act on one another in such a way as to greatly increase the development of their forces. In this machine iron bobbins wrapped with insulated wire are revolved between the poles of very feeble magnets made of soft iron. The electricity (small in amount when the machine is first put in motion) which is developed in the insulated wire of the bobbins passes, by means of a commutator, through convolutions of insulated wire surrounding the soft iron magnets, and renders them more highly magnetic. The magnetism of the soft iron magnets being thus increased, develops a correspondingly increased quantity of electricity in the revolving bobbins, which re-acts on the soft iron magnets, rendering them still more highly magnetic.

The expenditure of mechanical force giving motion to the machine is greater as the magnetism and electricity developed increase, the consumption of mechanical force having relation to the quantity of electricity rendered active.

1326. Gramme's Magneto-Electric Machine, for electrotyping. *H. Fontaine.*

1327. Gramme's Magneto-Electric Machine, for electric light. *H. Fontaine.*

1328. Gramme's Magneto-Electric Machine, for electric light of great power. *H. Fontaine.*

1329. Gramme's Magneto-Electric Machine, for demonstration. *H. Fontaine.*

1315. Magneto-induction Machine.
Gustav Baur, Stuttgart.

This apparatus, containing several electro-magnets and a current regulator, is furnished with double coils of wire, and may be used to set in action electric apparatus of very various resistance and with very quick interruption of current, *e.g.*, Ruhmkorff coils. In general, any experiments may be made with it that are made with batteries of 1-6 Bunsen elements. It is suitable, for medical purposes, galvanocaustics, &c., and, if a part of the rotating electro-magnets be wound with fine wire, for production of a constant current up to 60 Meidinger elements.

1330. M. Le Roux's Electro-Magnetic Apparatus, for showing the effect of magnetism on copper discs. *M. Ruhmkorff.*

1331. Model of a Magneto-Electric Machine, designed to illustrate the advantage gained by the use of an electro-magnet in place of the usual permanent magnet. *William Raynor.*

This model of a magneto-electric machine is one that has been constructed for the purpose of showing the great increase of the electric current by the use of an electro-magnet in place of the permanent magnet, when such magnet is excited or charged by a galvanic cell; and this plan may be applied with advantage to all magneto-electric machines using soft iron magnets.

1331a. Sketch and Description of an Improvement in Magneto-Electric Machinery. This improvement is obtained by using two armatures on one spindle, to be fixed one on each side of the magnet, and placing them at right angles to each other, so that one is in full action when the other is changing its polarity. *William Raynor.*

1332a. Portable Magneto-Electric Machine, with double coiled magnet. *Harvey, Reynolds, and Co.*

1249a. Volta Faradaic Machine, with arrangement in the pocket for taking shocks; also giving interrupted or continuous current, the batteries being of the constant Leclanché form.

Harvey, Reynolds, and Co.

1336. Dynamo-Electric Light Apparatus, making 480 revolutions per minute, with an expenditure of 6 horse-power gives a light of from 12,000 to 15,000 normal candles.

Siemens and Halske, Berlin.

In these machines the inner iron core is fixed. Around this core revolves a German silver bobbin, upon which is wound in a peculiar manner eight double circuits of covered copper wire, these circuits terminating in the metallic segments, which are successively brought as two opposite poles into contact with the wire brushes. The magnetic field in which this bobbin revolves (on its own axis) is formed by electro-magnets, the continuation of the cores of which are curved iron bars, and these bars are so arranged as to be brought as near as possible to the revolving bobbin. The current given by these machines is continuous and in one direction.

1336a. Dynamo-Electric Light Apparatus. This machine gives a light of 4,000 normal candles with 850 revolutions of the armature per minute, with an expenditure of work equal to 3 horse-power. *Siemens and Halske, Berlin.*

1336b. Dynamo-Electric Light Machine producing a light equal to 1,000–1,300 normal candles with about 1,100 revolutions of the induction cylinder per minute and an expenditure of 1 to 1½ H.P. The machine is 640 millimetres in length, 540 millimetres width, and 225 millimetres height.

Siemens and Halske, Berlin.

1336c. Magneto-Electric Machine to give a constant current. The apparatus has 50 steel magnets, and the current produced is equal to that from 8–10 Bunsen's elements. The armature is rotated by hand. *Siemens and Halske, Berlin.*

1336a. Various Examples of Magneto-Electric Apparatus.

Electro-magnetic machine by Gramme, with a Jamin magnet of 0·08m.

Magneto-electric machine, by Gramme, for electric light of 150 burners.

Magneto-electric machine, by Gramme, with electro-magnet for laboratory.

Magneto-electric machine, by Gramme, with a Jamin magnet (small model).

Magneto-electric machine, by Gramme, with a Jamin magnet (large model with fly-wheel and treadle).

Exploder, with Jamin magnet (large model) with bobbin, cable, and key.

Exploder, with Jamin magnet (medium model).

M. Bréguet, Paris.

1336d. Magneto-Electric Machine. *H. L. Rutter.*

f. OTHER MODES OF PRODUCING ELECTRICITY OR ELECTRIC CURRENTS.

1337. Apparatus, designed to obtain electric currents by means of the combined action of gravity and motion. Preliminary experiments only have yet been made with it.

George Gore, F.R.S.

1338. Apparatus for investigating electric currents produced by the friction of different metals. (Not yet completed.)

George Gore, F.R.S.

1341. Delezenne's Circle. An instrument for developing electrical currents by the agency of terrestrial magnetism.

Elliott Brothers.

1342. Apparatus by which **Forbes** procured an **Induction Spark** from a **Natural Magnet.** *Trans. R. S. Edin.*, 1833.

University of Edinburgh.

II.—APPARATUS FOR REGULATING THE PLACE AND TIME AT WHICH THE EFFECTS OF AN ELECTRIC DISCHARGE OR CONTINUOUS ELECTRIC CURRENT ARE PRODUCED.

1343. Six Specimens of Tubular Binding Screws for making electrical connexions. *George Gore, F.R.S.*

1343a. Specimens of Wire for Electric Apparatus.

1. Copper wires, covered with gutta-percha (1, 2, 25).

2. Copper wires, covered with gutta-percha and cotton (3).

3. Copper wires, covered with cotton (4, 5, 6, 9, 11, 12, 13, 14, 26).

4. Copper wires, covered with silk (7, 8, 10, 15 to 23, 27).

5. Elastic poires, with their cordons (24).

6. Covered wires of various metals, with statement of their resistance. *Madame Bonis, Paris.*

1235a. Apparatus for uniting several **Galvanic Elements** into one of large surface, so as to preserve the entire strength of the current by lessening the resistance.

Imperial University of St. Petersburg.

To effect this, two metal cylinders, each bored with seven holes parallel to the axle, and fitted with screws, are used. In one cylinder, the six ends of conductors connected with the positive electrodes (anodes) of the elements are inserted, and in the other, the six conductors connected with the negative electrodes (cathodes). The seventh hole is reserved for a conductor, the section of which is equal to the total section of the six other conductors. This last conductor issues from the opposite side of the cylinder. The apparatus here described is used by Prof. Petrouchevsky in St. Petersburg.

1345. Single Plug Key, to close or break contact for long or short durations. *Elliott Brothers.*

1346. Fall-hammer, to obtain perfectly equable closing of a circuit.

Prof. Engelmann, Physiological Laboratory and Ophthalmological School, Utrecht.

On a brass prismatic lever, movable round a horizontal axis, slides the bridge, a copper cover having underneath two amalgamated copper points. On depressing a spring the lever falls from a nearly vertical position, and plunges the bridge into two mercury vessels, movable on a horizontal slide, and connected with the battery. A spring prevents the bridge from rebounding. Velocity of fall to be regulated by moving the bridge on the lever with corresponding displacement of the mercury vessels on the horizontal slide.

The bridge being in the primary circuit of an induction apparatus, the breaking is every time to be effected at another place of the circuit, before lifting the bridge from the mercury, in order to prevent oxidization of the mercury by the spark.

The instrument can easily be managed with one hand.

1347. Firing Key, for torpedoes, &c. A simple contact key, with a movable piece of vulcanite, which can be brought between the two platinum contacts to prevent fatal results by accidentally closing the circuit. *Elliott Brothers.*

1348. Apparatus for reversing the direction of an Electric Current. Used with an electro-magnetic torsion apparatus. *George Gore, F.R.S.*

(*See* Philosophical Transactions of the Royal Society, Vol. 164, p. 529.)

1348a. Current-reversing Electrode.
J. Teller, München.

This gives a more convenient change of current than the commutators so far as electro-medical apparatus is concerned.

1349. Double Reversing Key, used for cable testing.
Elliott Brothers.

1350. Thomson's Reversing Key, used in connexion with the electrometer, for facilitating the measurement of the electrostatic capacity of a cable or condenser. *Elliott Brothers.*

1351. Lambert's Key, constructed for charging or discharging cables and condensers. *Elliott Brothers.*

1352. Spottiswoode's Rapid Break, for use with Intensity Coils. *Tisley and Spiller.*

By means of this break the discharge in vacuum tubes can be regulated, and the motion of the stratifications diminished or rendered stationary, as required. See Proceedings Royal Society, June 10, 1875.

1354. Forms of discharge on making and closing an induction current. *Prof. Donders, Utrecht.*

The trial with the noematachograph to have the instant of stimulation registered on the chronoscopic line by the current itself, led to the discovery :

1. That the discharge can form a long series of sparks.
2. That the electricity disappears more slowly when the spring rests on metal, more rapidly when it rests on a plate of mica, than in the form of sparks making holes in the paper. (Compare Onderzoekingen gedaan in het phys. labor. Ser. 2, T. III. 1870 ; and Wiedemann, Die Lehre vom Galvanismus und Electromagnetismus, 2^e Auflage, 1874, B. II., s. 360.)

1355. Drawings showing the patent system of lightning conductors applied to buildings. *J. W. Gray & Son.*

1356. Model of mid-section of a Ship, showing the patent system of lightning conductors applied to vessels in Her Majesty's service, &c. *J. W. Gray & Son.*

1357. Indestructible Solid Copper Tape Lightning Conductors. Small and large sizes. *Sanderson & Proctor.*

This form of lightning conductor possesses the greatest conducting surface. Hitherto it has been made in short lengths riveted together ; now it is made in any length without joints, thereby offering less resistance to the free passage of the electric current.

1358. Copper Rope Lightning Conductors, improved. The smallest and largest sizes. *Sanderson & Proctor.*

1359. New Lightning Conductor Apparatus.
Prof. Carl Wenzel Zenger, Prague.

This apparatus consists of lightning conductors arranged symmetrically, balls being used instead of conical points. A plan shows its application to the I. R. Real School, and to the National Theatre at Prague.

1360. Top of Lightning Conductor. The lower part is made of gun metal, the upper of copper, and the extreme point of gold or silver. Constructed according to the instructions of Professor Ed. Hagenbach-Bischoff, in Basle. *G. Linder, Basle.*

The electricity escapes easily through good conductors from points and edges; the point does not oxidize in the atmosphere, and being a good conductor is not liable to be melted by electricity.

1361. Needle of Lightning Conductor, brass gilt.
Geneva Association for the Construction of Scientific Instruments.

1362. Lightning Conductors (various kinds).
John Faulkner.

Two photographs of expedients for applying lightning conductors to high spires and factory chimneys, and for the repair of high spires and chimneys.

1363. Models of Lightning-Conductors of the latest construction. *Mittelstrass Brothers, Magdeburg.*

1364. Apparatus serving **for the separation and collection of induced currents,** constructed by Dr. Th. Tasché, manufactured by Staudinger & Co., in Giessen.
Dr. Tasché, Giessen.

1364a. Current Analyser, with glass axis, made by Jung, of Giessen. *Physical Institute (Univ. of Giessen), Dr. Buff.*

The "current analyser" can be occasionally used for experimental research in voltaic induction, to separate the two induced currents, and to study the proportion of their intensities or electro-motive forces. *See* Poggendorff's Annalen, Vol. 127, p. 57.

1365. Binding Screws for **Galvanic Work.**
M. Th. Edelmann, Munich.

1366. Current-key for **Beetz's Compensation Method.**
M. Th. Edelmann, Munich.

III.—APPARATUS FOR ACCUMULATING ELECTRICITY.

1367. Leyden Jar of five and a half square feet coated surface. *Teyler Foundation, Haarlem.*

This jar is one of the 100 jars arranged in four cases, by which Van Marum constructed a battery of 550 square feet coated surface. The coatings of

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tinfoil have been renewed recently; but all is restored in the form in which it was used by Van Marum.

See Van Marum, "Machine Électrique," II., p. 195.

1368. Leyden Battery of 15 jars.

Teyler Foundation, Haarlem.

This battery is one of 16 used by Van Marum for his famous experiments, giving a total coated surface of 225 square feet.

The coatings of tinfoil have been renewed recently; the bottom of tea-lead in the case is also restored; and the outer coating of the case bottom, which Van Marum also made of tea-lead, has been replaced by zinc.

See Van Marum "Machine Électrique," I. p. 155, and II. p. 3.

1369. Battery of 10 one-gallon Leyden Jars.

Frederick Guthrie.

This battery stands in a mahogany frame. The jars stand upon perforated zinc. There is an arrangement for drying them by a current of hot air. The spark from this battery deflagrates a platinum wire a foot long.

1369a. Series of Leyden Jars, with connectors, and ebonite covers, 10 pieces from 90 to 100mm. high.

Warmbrunn, Quilitz, & Co., Berlin.

1369b. Battery of Leyden Jars, consisting of six jars 312mm. high, in mahogany case. *Warmbrunn, Quilitz, & Co., Berlin.*

1369c. Cylinder, on insulating support.

Warmbrunn, Quilitz, & Co., Berlin.

1369d. Cylinder, with elder-pith balls.

Warmbrunn, Quilitz, & Co., Berlin.

1369e. Sphere, on insulating support, with two movable hemispheres on ebonite rods. *Warmbrunn, Quilitz, & Co., Berlin.*

1369f. Large dissected Leyden Jar.

Warmbrunn, Quilitz, & Co., Berlin.

1370. Spiral Leyden Jar. *Frederick Guthrie.*

Two sheets of ebonite, alternating with two sheets of tinfoil, are rolled up together. The central knob is connected with the inner edge of one of the foils; the brass girdle is connected with the other sheet. A Leyden jar is thus formed which is compact with a large surface.

1371. Mica-plates for insulating electrical apparatus.

Max. Raphael, Breslau.

Mica can be rendered electrical by the least friction, hence its frequent employment as an excellent insulating material, especially on account of the facility with which it can be worked.

1372. Two Large Condensers, consisting of Leyden jars, each 400 millimeters high and 200 millimeters in diameter.

Borchardt, Hanover.

1372a. Adjustable Disc Condenser, which has also been used as a spark micrometer. *Sir William Thomson.*

It was in this instrument that the sound produced in an air condenser by a sudden change of potential was first heard. The lower part of the cell is arranged to hold cups of pumice-stone impregnated with sulphuric acid.

1372b. Cylindrical Condenser, for measuring capacity in absolute electrostatic units, described in Messrs. Gibson and Barclay's paper in the Transactions of the Royal Society for 1871. *Sir William Thomson.*

1372c. Condenser for the Holtz-Bertsch Electrical Machine. *Mottershead & Co., Manchester.*

IV.—APPARATUS FOR PRODUCING AND OBSERVING EFFECTS OF ACCUMULATED ELECTRICITY.

1373. Apparatus for demonstrating the fundamental laws of electrical and magnetical attraction and repulsion, made according to the instructions of Professor Ed. Hagenbach-Bischoff, in Basle. *G. Linder, Basle.*

The ebonite rods are negatively electrified when rubbed with fur, and positively electrified when rubbed with gun-cotton. (*See* Carl, Repertorium der Experimental-Physik, VIII., p. 75.)

1374. Insulated Pith-Ball Stand, with mahogany arm; the arm is itself a box in which the pith balls may be placed when it is not in use. *The Council of King's College, London.*

1648. Series of Elder Pith Figures, Butterflies, &c. *Warmbrunn, Quilitz, and Co., Berlin.*

V.—APPARATUS FOR PRODUCING AND OBSERVING EFFECTS OF THE DISCHARGE OF ACCUMULATED ELECTRICITY, WITH SPECIMENS OF PERMANENT RESULTS PRODUCED.

1375. Photographs of **Sparks** from a **Holtz Machine,** in cold and in heated air. (See Trans. R. S. Edin., 1874–5.) Taken by an instantaneous process, a quartz lens being employed. *Prof. Tait.*

1375b. Spark Micrometer after Riess. *Warmbrunn, Quilitz, & Co., Berlin.*

1376. Apparatus used by M. Rijke to measure the distances at which the spark of the Leyden jar passes. *Prof. Dr. P. L. Rijke, Leyden.*

1377. Vacuum Tube for electric discharge. 1856.
Teyler Foundation, Haarlem.

Masson in Paris used a Torricellian vacuum sealed by the lamp, in his extensive researches on the electric spectrum. Some time afterward, Dr. Geissler, in Amsterdam, made this Torricellian vacuum at the instigation of Prof. Van der Willigen, now director of the Teyler Museum, whose property it is at present. The experiments with this tube are described in Poggendorff's Annalen, vol. xcviii. p. 487, 1856. Subsequently Dr. Geissler in Bonn constructed his various well-known and beautiful tubes. This tube contains a little mercury and carbonic oxide gas.

1377a. Four Geissler's Vacuum Tubes. *E. Cetti and Co.*

1377b. Collection of Geissler's Tubes.
Dr. H. Geissler, Bonn.

1377c. Tube, by Geissler, for two gases.

Tube, by Geissler, forming a diadem.

Tube, by Geissler, forming a diadem.

Tube, by Geissler, with inner spiral.

Tube, for liquids, with six spirals.
Alvergniat Frères, Paris.

1377d. Three Vacuum Tubes, to show the connexion between the resistance of rarefied air and the phenomenon at the cathode, the so-called negative glow. *Prof. Hittorf, Münster.*

Apparatus (A) made by Dr. Geissler, of Bonn, consists of two balls which communicate together by two tubes of equal width, one short and one of spiral form $3\frac{3}{4}$ mètres long. The electrodes of aluminium wire pass through the balls and end in the short tube so that there is a free interval of only 2 mm. between them. The opening current of the Rhumkorff coil passes, in consequence of the great rarefaction of the air in the tube, not by this short path, but prefers the longer one. If the latter be stopped by closing the glass cock, the passage is effected, but only at much greater tension, by the short path. The tube (B) has the same arrangement, but without the glass cock. It is used in place of (A) where the air is able to penetrate and the required vacuum ceases. The glass vessel (C) consists of a wide reservoir and a cylindrical tube, each of which holds one of the two equally long wires as electrodes. The tension of electricity with which passage occurs is much greater when the wire in the narrow part serves as cathode than when it is anode. This may be shown if a spark micrometer be introduced in the induction current near the tube, and for each of the two directions the interval of the balls be determined with which the current takes the path through the tube. If the wire in the wide reservoir, being cathode, be placed in conductive connexion with the third aluminium wire, which is in the beginning of the cylindrical tube, the current can no longer pass over in the latter to the former This, therefore, loses its negative light, and only with the greater tension, such as occurs with the other direction, is the passage of electricity effected. (Cf. Pogg. Ann., Bd. 136, p. 197.)

1377e. Three Tubes of Glass, with rarefied air to show the magnetic behaviour of the negative light.

Prof. Hittorf, Münster.

The aluminium wire, which is quite sheathed with glass, with the exception of the end, is taken as cathode of the opening induction-current. The straight discharge from the cross section, when the tubes are brought over and between the poles of an electro-magnet, behaves like a flexible conductor which is fixed at one end and at the other freely movable, and follows the Laplace-Biot laws. (Cf. Pogg. Ann., B. 136, p. 213.)

1377f. Three Glass Tubes of Rarefied Air and Sulphide of Calcium, to show the phosphorescence of the negative electric light. *Prof. Hittorf, Münster.*

The negative electric discharge which, with great rarefaction, occurs at a cathode with small surface, raises the conducting particles of gas to a very high temperature. When strong induction currents are used, these, notwithstanding their small mass, are capable of raising the surface of badly-conducting solid bodies with which they come into contact to a red heat. This heating, which the negative discharge gives in much greater degree than the positive, produces with the best light-givers, like sulphide of calcium, a light of dazzling intensity.

1378. Gassiot's Star. *Frederick Guthrie.*

This exhibits (1) the varieties of the electric discharge through various rarefied gases in tubes of different shapes, and (2) by being rotated shows by the retention of images the intermittent nature of the discharge.

1379. Block Specimen of Glass, 2½ inches high, penetrated vertically by an electric discharge. (By Ruhmkorff, of Paris.)

George Gore, F.R.S.

1380. Effect of Lightning. Portion of a half-sovereign and a fragment of sheet iron fused together by a discharge of lightning in the colony of Natal. This and other coins were in a tin box, of which this fragment alone remained after the passage of the discharge. *Robert James Mann, M.D.*

1381. Metals fused into Glass by Lightning.

Alfred B. Harding.

Frame No. 1 consists of strips of zinc, tin, and lead, fused into glass by an actual flash of lightning, collected by means of "exploring wires" stretched over the grounds of the late Andrew Crosse, and conveyed into his electrical room, as shown in the stereograph. It was here accumulated in the great Leyden battery of 50 jars, and passed thence by dischargers through the metals, which were burnt into the glass on which the strips were laid.

Frame No. 2 contains composite strips of copper and iron, gold and tin, and gold, silver, and copper, fused in like manner.

A photograph of the Leyden battery, with which the experiments were performed, accompanies the frames.

1382. "Thunder House," or model to illustrate the identity of lightning and electricity, and the use of lightning conductors

in protecting buildings—said to be the first model of the kind, and to have been made by Dr. PRIESTLEY with his own hands.
Conrad Wm. Cooke, M. Soc. T.E.

1383. Old Electric Egg (beginning of last century). The property of Prince Pless. *The Breslau Committee.*

The great age of the instrument appears both from tradition and from the style of the wooden frame and the nature of the brass work. It is certainly one of the oldest instruments of the kind.

1384. Apparatus employed by Sir Charles Wheatstone to determine the **Velocity** and **Duration** of the **Electric Discharge.**

Rotating mirror. Spark disc. Early rotating disc with balls and sliding rod. *The Council of King's College, London.*

1385. Riess' Spark Micrometer. *F. Rob. Voss, Berlin.*

1386. Apparatus for testing Lightning Conductors.
M. Th. Edelmann, Munich.

1387. Electrograph, for the production of electric sand-figures, constructed, from the plan of the exhibitor, by M. Th. Edelmann. *Prof. W. von Bezold, Munich.*

This serves for the study of the nature of the electric discharge in simple or branched circuits, with the aid of sand-figures. The figures exhibited have partly been produced with this apparatus, partly under the air pump, and by means of a caoutchouc solution transferred from the ebonite plate to black tissue-paper. They are accordingly not copies, but true originals, produced by the discharge.

1388. Framed Table, with electric sand-figures.
Prof. W. von Bezold, Munich.

VI.—APPARATUS FOR PRODUCING AND OBSERVING EFFECTS OF CONTINUOUS ELECTRIC CURRENTS.

a. HEATING AND LUMINOUS EFFECTS.

1389. Diagram showing the **Amounts** of the **Electro-motive Force,** and the **Peltier** and **Thomson Effects** in a **Thermo-electric Circuit** of **Iron-Copper,** both junctions being at temperatures under the neutral point. For teaching purposes.
Prof. Tait.

1390. Peltier's Apparatus, for studying the thermal effects of currents in circuits composed of two or more metals.
Conservatoire des Arts et Métiers, Paris.

b. CHEMICAL EFFECTS.

1391. Apparatus for the polar **Decomposition** of **Water** by means of atmospheric electricity or the currents of the ordinary electrical machine. The gases are collected in fine thermometer tubes, by which means their absorption by the electrolyte is avoided.
Dr. Andrews, F.R.S.

1391a. Warmbrunn, Quilitz, and Co.'s Apparatus for Decomposition of Water, peculiar construction, with graduated tubes for the separated gases and for detonating.
Warmbrunn, Quilitz, & Co., Berlin.

1392. Bottle, containing fragments of pure **Electro-deposited Metallic Antimony.** *George Gore, F.R.S.*

(*See* Philosophical Transactions of the Royal Society, 1857, 1858, and 1862.)

1393. Two Specimens of **Electro-deposited Antimony;** one of the explosive, and one of the pure variety.
George Gore, F.R.S.

1394. Rare Specimen of pure Carbon, deposited by means of an electric current upon a rod of platinum.
George Gore, F.R.S.

c. ELECTRIC DIFFUSION AND CHANGE OF SURFACE-TENSION.

1395. Apparatus for producing Vibrations and Sounds, and an intermittent electric current by means of the electrolysis of a solution of cyanide of potassium and mercury with electrodes of mercury. *George Gore, F.R.S.*

The effects are produced by the alternate rapid formation and destruction of films upon the positive electrodes. (*See* Proceedings of the Royal Society, Vol. 12, p. 217.)

1395a. Electro Capillary Force Machine, after Lippmann.
R. Jung, Heidelberg.

To set this machine in action, the two wide glass vessels are first filled to a height of 1 to 3 cm. with mercury, placed in position in the glass trough, and then two thirds filled with pure dilute sulphuric acid. Then the two bundles of thin glass tubes are pushed repeatedly down into the mercury, so that the air is driven out, and the tubes and their interstices are quite filled with mercury and acid. The bundles are then fixed by screws to their frames, so as to be about half immersed in the mercury, and to stand in equilibrium in the middle of their respective vessels. If the cups of the key be now filled with mercury, and the crank, which works it, so placed that the current is reversed a little before the opposite crank comes to its dead point, the machine (having been connected with the poles of a Daniell battery) will commence working, and may make as many as 100 revolutions in a minute. A Meidinger element keeps the machine in action for months.

1395b. Apparatus for electric osmose.

Prof. Hittorf, Münster.

In each of the three divisions formed in the glass cylinder by the clay plates the electric endosmose (when the vessel is quite filled with the solution of an electrolyte) is produced or prevented according as, on passage of the current, the three openings are free or are closed. With the arrangement it is proved that the transference of the ions is quite independent of the electric endosmose. (Pogg. Ann., Bd. 96.)

d. EFFECTS DUE TO THE FORCE BETWEEN CURRENTS AND MAGNETS.

1396. Apparatus for showing the Rotation of a Bar-magnet on its axis by the passage through it of an electric current. *George Gore, F.R.S.*

(*See* Proceedings of the Royal Society, Vol. 24, p. 121.)

1397. Apparatus for showing the Rotation of a Copper Wire upon its axis between the poles of two magnets by passing through it an electric current. *George Gore, F.R.S.*

(*See* Proceedings of the Royal Society, Vol. 24, p. 121.)

e. EFFECTS DUE TO THE FORCE BETWEEN CURRENTS AND CURRENTS.

1398. Apparatus for demonstrating the Laws of Ampère.

Geneva Association for the Construction of Scientific Instruments.

The mode of suspension used in this apparatus allows the conductor to make a complete revolution.

The current passes from the movable conductor into an annular cup, concentric with the axis of motion and filled with a conducting liquid.

All the conductors are made of aluminium so as to lessen their weight as much as possible.

The apparatus may be used for a great number of experiments; it is specially adapted for the following demonstrations:—

1. Parallel currents in the same direction attract one another, and those in contrary directions repel one another.
2. Inclined currents in the same direction attract one another, and those in contrary directions repel one another.
3. The attraction and repulsion of the same current are equal.
4. A sinuous current acts like a rectilinear current of the same general direction and having the same extremities.
5. A closed current takes a direction perpendicular to the magnetic meridian.
6. A solenoid has the essential properties of a magnet.
7. The elements of the same current repel one another.

The mutual action of magnets and currents is demonstrated by means of the same apparatus, by replacing one of the currents by one or more magnets.

1398a. General Table, by Ampère, with apparatus used by him in the discovery of the action of currents.
College of France, Paris.

1399. Apparatus for demonstrating the action of Metallic Discs in movement upon a metallic wire used as a voltaic conductor. *Prof. Daniel Colladon, Geneva.*

Experiment performed on 4th September 1826, in presence of the Paris Academy of Sciences, by Messrs. Ampère and Colladon.

Bulletin de Sciences Mathématiques, by De Férussac, vol. 6, p. 212.

1400. Model of a Circular Railway, for showing the rotation of a metal ball upon it by the passage of an electric current. *George Gore, F.R.S.*

(*See* Philosophical Magazine, Feb. 1859.)

1400a. Small Model of a Circular Railway, for showing the rotation of a metal ball upon it by the passage of an electric current. (*See* Philosophical Magazine, February 1859.)
George Gore, F.R.S.

VII.—APPARATUS FOR REGULATING THE STRENGTH OF ELECTRIC CURRENTS.

1402. Wheatstone's Rheostat, or changeable resistance, for quickly adding or removing a low resistance. *Elliott Brothers.*

1403. Voltastat and Voltameter combined.
Frederick Guthrie.

Air-tight through the stopper of a cylindrical vessel containing dilute sulphuric acid pass the following: (1.) Two platinum wires coated with glass. (2.) A long and wide tube open at both ends, the lower end reaching to the bottom of the cylinder. (3.) A tube opening freely beneath the stopper and above it by a very fine capillary aperture. The platinum wires are enlarged into platinum plates of triangular form, with their apices downwards, and further apart than their bases. Increase in the current passing by means of the wires between the electrodes causes the liquid to rise higher in the manometer tube, and also, by laying bare the electrodes, increases the resistance.

1404. Voltaic Compensator, an apparatus for maintaining the electric current derived from any sort of voltaic battery at constant intensity.
Elie Wartmann, Professor of Natural Philosophy at the University of Geneva.

A full description of this instrument is printed in the "Archives des Sciences physiques et naturelles," January 1858. In addition to the principal current, which, if constant, would do the work required, there is an auxiliary one, the strength of which is kept down by inserting an additional resistance. This resistance diminishes with the weakening of the principal current, and the consequent increase of the auxiliary current compensates that weakening.

1404a. Regulator, by Foucault. *M. J. Duboscq, Paris.*

1405. Apparatus to make the **Electric Light,** derived from a **Voltaic Battery,** constant in its position and intensity.
Elie Wartmann, Professor of Natural Philosophy in the University of Geneva.

This apparatus, called *fixateur* for the electric light, was used in the years 1856 and 1857 for lighting the harbour of Geneva. A full description is to be found in the "Archives des Sciences physiques et naturelles," December 1857. By means of an electro-magnet and of gravity, two points of carbon are placed and kept at such a distance that the light produced by the current of an electric battery may be as bright as possible.

1406b. Regulator of Electric Light, by Serrin, with glass globe. *M. Bréguet, Paris.*

1406. Regulator of Electric Currents, after the plan of M. Mascart. *M. Redier.*

1407. Regulator for the Electric Light. *M. Carré.*

1408. Artificial Charcoal Sticks for the Electric Light. *M. Carré.*

1409. Electric Lamps, 1 small and 1 large. These lamps are automatic in their motion ; in them the carbon points are caused to approach or recede from each other.
Siemens and Halske, Berlin.

1409. Electric Lamps. These lamps are automatic in their action, in them the carbon points are caused to approach or recede from each other as required, without the aid of clockwork.
Siemens and Halske, Berlin.

VIII.—APPARATUS FOR DETECTING AND MEASURING DIFFERENCES OF ELECTRIC POTENTIAL AND CURRENTS OF ELECTRICITY.

a. ELECTROSCOPES AND ELECTROMETERS.

1410. Two Repulsion Electrometers constructed and used by Van Marum. *Teyler Foundation, Haarlem.*

1411. Small Pocket Electroscope used by **H. B. de Saussure** during his excursions in the Alps.
M. H. Henri de Saussure, Geneva.

1412. Insulating Stand, with **Air Chamber,** artificially dried by sulphuric acid, used in connexion with first portable atmospheric electrometer. *Sir William Thomson.*

This stand was ordinarily attached to the top of the electrometer, as figured in Nichol's Cyclopædia, Art. Electricity (atmospheric), and in Thomson's Reprint of Papers on Electrostatics and Magnetism, XVI., 263. Sometimes—as in observations to determine in absolute measure the electric force in the atmosphere, on the sea beach, and in boats in Brodick Bay, Isle of Arran (reprint XVI., 281), and, with the assistance of Dr. Joule, on the Links of Aberdeen (British Association meeting, 1851)—the stand was detached from the electrometer and laid on the ground at a distance from it with connexion by fine wire to the insulated part of the electrometer, which also was placed on the ground, and was read by observer lying as close to the ground as possible.

1413. Atmospheric Portable Electrometer, No. 2, altered for first trial of divided ring principle for a quadrant marine electrometer, and used successfully on board the "Great Eastern," though not in connexion with the cable, in 1865. *Sir William Thomson.*

This instrument has not been repeated, nor described in print, but it may yet do good service at sea. Made by James White, Glasgow.

1413a. Sir Wm. Thomson's Quadrant Electrometer, with most complete adjustments and of most perfect construction. *James White.*

A descriptive pamphlet accompanies the instrument.

1413b. Sir William Thomson's Portable Electrometer, with most complete adjustments, and of most perfect construction. *James White.*

1413c. Electric Sensitizer. *Sir William Thomson.*

This instrument is an induction electric machine, and is used with the portable electrometer or other electrometer for testing the potential of a conductor without removing any part of its charge.

1414. Atmospheric Portable Electrometer, No. 4, altered to a plan for marine electrometer, which was discarded soon after trial. *Sir William Thomson.*

1415. Atmospheric Portable Electrometer, No. 5. Perfected portable electrometer, on same general plan as No. 1, described fully in Friday Evening Lecture to the Royal Institution, May 18th, 1860 (Thomson's Reprint of Papers on Electrostatics and Magnetism, XVI., 277). Made by James White, Glasgow. *Sir William Thomson.*

1416. Atmospheric Portable Electrometer, No. 10. First of new plan described in report on electrometers and electrical measurements (British Association Report for 1867, Committee

on Standards of Electrical Resistance, and Thomson's Reprint of Papers on Electrostatics and Magnetism, XX., 368).
Sir William Thomson.

In this first instrument the attracting disc turns with a micrometer screw instead of moving in a geometrical slide, as in the portable electrometers now made. The receptacle for pumice and sulphuric acid was dangerously placed in the roof. This instrument was designed and first tried in the Island of Arran in 1862. Made by James White, Glasgow.

1417. Attracted Disc Heterostatic Station-Electrometer on same electric principle as latest portable electrometers, but with mechanism inverted. *Sir William Thomson.*

This instrument is of convenient dimensions and general plan for stationary observations of atmospheric electricity and various electrostatic measurements. Made by James White, Glasgow.

1418. Large Portable Electrometer of same general plan as No. 10, altered to measure distance between two metallic conductors giving sparks with electro-motive force measured by another electrometer, in continuation of Smith and Ferguson's measurements. (Proceedings of the Royal Society, 1860, and Thomson's Reprint of Papers on Electrostatics and Magnetism, XIX., 320.)
Sir William Thomson.

Numerous accurate experiments were made many years ago by this piece of apparatus, but the results have not hitherto been published. Made by James White, Glasgow.

1420. Station Electrometer. *Sir William Thomson.*

This electrometer was used by Professor Everett in his two years series of observations on atmospheric electricity at Windsor, Nova Scotia, described in the Transactions of the Royal Society of London for 1868. Its electric principle is the same as that of No. 8 of the perfected form of portable electrometer of the first kind. (See Thomson's Reprint, xvi. 777.)

1421. First divided Ring (semi-circular) **Electrometer.**
Sir William Thomson.

This was used for several years in the University of Glasgow, and described in the Accademia Pontificia dei Nuovi Lincei, February 1857, and in Thomson's Reprint, xviii. 311.

The movable electrified body projects from one side of the bearing wire far enough to travel over the flat semi-circular rings and experience their electric force. It is kept electrified by a fine platinum wire dipping in sulphuric acid, which forms the outside coating of the Leyden jar below it.

1422. Attracted Disc Electrometer, with double micrometer screw, arranged, to give the same period of free oscillation with different forces at different distances. *Sir William Thomson.*

The lower disc is insulated, the upper connected with the metal work of the case of the instrument and of the micrometer screws by a spiral spring by which it is hung. By turning the torsion head, the upper end of the spring and the sight-marks with movable stops for the lower end of the spring, are moved through different distances, of which the former is $1\frac{1}{2}$ times the latter.

The instrument exhibited was made 15 or 20 years ago. The present condition of the spiral spring shows that it has become elongated through time, without stress, because the hook at its lower end, bearing the disc, rests firmly against the lower stop, with the stop in the lowest position that the micrometer screws allow.

1423. First Mirror divided Ring (semi-circular) **Electrometer,** used at Kew for recording atmospheric electricity.
Sir William Thomson.

A specimen of the curve by which it recorded the atmospheric potential is published in Thomson's reprint, xvi. 292. Specimen sheets of its actual work accompany the instrument.

1424. First Trial Apparatus, towards mirror quadrant electrometer. *Sir William Thomson.*

This instrument was first designed for marine use. The mirror and needle are supported on a stretched bundle of silk fibre, as are the needle and magnets of the marine galvanometer. The electric connexion between the needle and the inside coating of the Leyden jar is made by a spiral of fine platinum wire. These peculiarities were tested and found to work moderately well in the trial instrument now exhibited, but have never been repeated; nor does it seem very desirable they should be repeated, as the balancing of the needle on this plan, with sufficient accuracy for good work at sea, would probably be more troublesome than the object would justify. The electric action of this instrument was found so promising that immediately instruments were constructed on the same electric plan for use on land. The shape and dimensions of the suspended needle and of the electrified surroundings of the mirror are precisely the same as those of the quadrant electrometers now made. The improvements upon this original working model consist of geometrical slides for the quadrants, mechanical details regarding the suspension, the substitution of a fine platinum wire hanging down into the liquid in the bottom of a tall Leyden jar for the platinum spiral, and the addition of a replenisher and gauge for the charge of the jar.

1425. Divided Ring (semi-circular) **Electrometer,** described in Nichol's Cyclopædia, article Electricity (Atmospheric).
Sir William Thomson.

1426. Improved Helmholtz's Quadrant Electrometer.
T. Rob. Voss, Berlin.

This is well suited for school use, as it is not very expensive, and its action is, in proportion, as good as that of larger machines.

1427. Electrometer. *E. Stöhrer, Leipzig.*

1428. Kohlrausch's Torsion-electrometer.
Prof. Wüllner, Aix-la-Chapelle.

1429. Kohlrausch's Sine-electrometer, with two needles of different magnetic moment. *Prof. Wüllner, Aix-la-Chapelle.*

1430. Kohlrausch's Condenser.
Prof. Wüllner, Aix-la-Chapelle.

All three pieces of apparatus were manufactured by Th. Schubart, of Ghent and Marburg.

The detailed description and theory of Kohlrausch's various apparatus may be found as under :—

Poggendorff's Annalen, Vols. 72 and 74 for the torsion-electrometer.
" " Vol. 88 for the sine-electrometer.
" " Vols. 75 and 88 for the condenser.

The apparatus which are exhibited show the forms which Th. Schubart (late of Marburg, and now of Ghent) makes at the present time. A good description of the present forms is given in Wüllner's "Lehrbuch der Experimental-Physik," Vol. 4, 3rd edition, p. 159, and p. 299.

1431. Edelmann's Quadrant-electrometer.

M. Th. Edelmann, Munich.

1431a. Electrometer for measuring potentials, and particularly the potential of an accumulator at the moment of the discharge. *Prof. Augustus Righi, Bologna.*

1431b. Induction Electrometer.

Prof. Augustus Righi, Bologna.

A caoutchouc tube carrying several copper rings is wrapped round the non-insulated pulleys (2, 4). If the insulated inductor (1) is charged, the rings go from (2) to conductor (3), with charges of contrary sign, and these charges remain in the insulated conductor (3). For, as the rings touch the conductor (3) by means of a little pulley placed in its interior, the charge preserved by any single ring is slight. For a very small charge of the inductor, the conductor (3) acquires a charge great enough to be shown by a gold leaf electroscope. If the inductor is uncharged, and the pulleys and the rings are of the same metal and very clean, the conductor (3) remains uncharged.

In open places the conductor (3) is charged by the sole influence of atmospheric electricity.

1432. Ronalds' Electrical Apparatus, as employed by him at the Kew Observatory; consisting of a principal conductor, with its glass support, umbrella, and heating apparatus; its voltaic collecting lantern; Volta's electrometers and sights; a Henley electrometer; a Gourjon galvanometer; a discharger, or spark measurer; and a Bennet's gold-leaf electroscope.

Kew Committee of the Royal Society.

Apparatus erected in the equatorial room of the Kew Observatory, in 1843, by Mr. Francis Ronalds, for the purpose of observing atmospheric electricity, described in the British Association Report for 1844.

It consists of a principal conductor, which is a stout copper tube, passed through a large aperture lined with sealing-wax in the roof of the building in which the instrument was placed, and carrying an inverted copper tray, to exclude rain.

The tube is supported by a stout glass core, which is kept in a dry state by a copper funnel passing up its interior, kept constantly heated by a small lamp.

A second lamp is enclosed in a Volta's collecting lantern, fixed to the top of the collecting tube.

To the cross arms at the base of the tube are attached severally:—Volta's electrometers with ivory scales, and sights for accurately determining the angles of the deflection of the straws; a Henley, or quadrant electrometer;

a galvanometer, by Gourjon (the property of Sir C. Wheatstone); a discharger, or spark measurer; and a Bennet's gold-leaf electroscope.

Continued regular observations were made with these instruments for several years.

The wooden stand now exhibited was not the original table upon which they were placed; that, a fixture in the Observatory, having been destroyed.

The Henley electrometer has also been replaced by a less perfect instrument.

1433a. Box Electroscope, avoiding the faults of common gold leaf electroscopes. *Prof. Beetz, Munich.*

1433b. Bifilar Electroscope, with copper, zinc, and condenser-plates for showing Volta's fundamental experiments, and tourmaline for showing pyro-electricity. *Prof. Beetz, Munich.*

1434. Thomson's Divided Ring Electrometer and **Gauge,** formerly in use for recording atmospheric electricity, at the Kew Observatory.

Kew Committee of the Royal Society.

This instrument, which consists of two parts, the electrometer and the gauge, was erected at the Kew Observatory in 1861, in connexion with a photographic recording apparatus, and worked there for about four years, producing daily records of the fluctuations, &c. of atmospheric electricity, which were discussed by Professor Everett, and the results published, together with a description of the instrument, in the Philosophical Transactions for 1868, Pt. I.

It has since been replaced by an improved quadrant electrometer.

1435. Singer's Gold Leaf Electroscope, for lecture purposes. Large size. *Elliott Brothers.*

1436. Quadrant Electrometer, being a modification of Sir W. Thomson's delicate quadrant electrometer, used for measuring the difference of potential between two conductors.

Elliott Brothers.

1437. Peltier Electrometer, for measuring the electrical tension of a charge by the repulsion of a light aluminium needle, which receives a directive force from a very small magnet attached to it. *Elliott Brothers.*

1437a. Peltier Electrometer.

The British Telegraph Manufactory, Limited.

1438. Capillary Electrometer, after Lippmann.

R. Jung, Heidelberg.

A glass tube *a*, filled to a height of about 85 cent. with mercury, and ending below in a fine point, dips in a cylinder *b*, so that its point presses lightly against the side, where there is a microscope *c* placed horizontally. The bottom of the cylinder contains mercury, and above this there is dilute sulphuric acid which covers the point of the tube; a platinum wire, connected with one terminal of the apparatus and protected by a glass tube from the sulphuric acid, dips into the mercury. The long tube is connected above with a small glass inverted U-tube, in which a platinum wire is fused, which, reaching down into the mercury in the tube, forms the upper electrode. The other end of the U-tube is connected by caoutchouc tubing with an air press, which, on its other side, is connected with a manometer. A little mercury is first forced through the fine point by means of the press. The microscope is then so placed that the zero point of the eyepiece micrometer coincides with the image of the meniscus of mercury in the capillary tube; then the electric source to be measured is brought into the circuit of the apparatus, its negative pole being connected with the upper electrode. The mercury forthwith retires, and can only be brought back by a determinate pressure with the press.

1439. Coulomb's Torsion Balance, for measuring magnetic and electric attraction and repulsion. *Elliott Brothers.*

1439a. School Form of Coulomb's Torsion Balance. *Harvey, Reynolds, and Co.*

b. GALVANOMETERS.

61. Galvanometer for hydro-electrical currents, with which Matteucci discovered, in 1844, the muscular current.
The Royal Institute of "Studii Superiori" at Florence.

The Copley medal was awarded by the Royal Society to Matteucci for his electro-physiological labours, and above all for his discovery of the muscular current.

Galvanometer of Nobili, with astatic system, and bobbin composed of eight threads to be united at pleasure.
The Royal Institute of "Studii Superiori" at Florence.

Galvanometer of Nobili, with astatic system for the hydro-electrical current.
The Royal Institute of "Studii Superiori" at Florence.

56. Magnetoscope of Nobili, composed of an astatic system suspended in a glass bell furnished with a graduated circle.
The Royal Institute of "Studii Superiori" at Florence.

The first galvanometer upon the astatic system was made by Nobili, in 1825. He afterwards so improved galvanometers, that they could be adapted to every kind of current, and be perfectly similar to one another. As to the magnetoscope, he made use of it to detect the slightest traces of magnetism.

1235b. Large-sized Galvanometer, for demonstrating the principal applications of Ohm's formula.
Imperial University of St. Petersburg.

It consists of a strong brass ring, below which are two long plates, fitted at their extremities with an adjustment for uniting the galvanic couples parallel-wise (in quantity). Another ring, with more than 400 turns of wire, serves to study the combination of the couples in a different way. The two rings are united together, and can be set different distances from the needle. The needle is furnished with two index-arms crossing each other at right angles, the four ends of which are bent downwards at right angles, so as to mark the deflection upon a graduation placed round the outer vertical surface of a cylindrical ring.

This apparatus, for demonstration, is constructed according to the directions of Prof. Petrouchevsky, Professor at the University of St. Petersburg.

1440. Galvanometer with variable resistance.

Prof. Dr. R. A. Mees, Director of the Physical Laboratory of the University of Groningen.

This galvanometer can be used for hydro-electric as well as thermo-electric currents. By its aid the dependence of the sensibility of a galvanometer on its resistance can be demonstrated.

1441. Reflecting Astatic Galvanometer, with coils of low resistance, and with telescope and scale, for measuring thermo-electric currents of very low intensity. Focal distance of telescope and scale about three metres. Made by Ruhmkorff, of Paris.

George Gore, F.R.S.

1442. Galvanometer, by **Colladon,** with wires insulated by a special method. This instrument was used by the inventor for measuring the intensity of currents produced by electric friction machines, by electricity from the clouds in 1826, and by electric fish in 1831. *Prof. Daniel Colladon, Geneva.*

The inventor used this same galvanometer in 1831, for studying the distribution of the electric poles upon torpedoes, and the strength of currents produced by animal electricity.

Annales de Chimie et de Physique, 1826, vol. 33.

Péclet, Traité de Physique, 1832, vol. 2, p. 221 to 225.

Mémoires de l'Académie Royale des Sciences, Institut de France, vol. 10, p. 74.

1443. Balance Galvanometer, giving indication of current in grains or other weights in scale pans, which may be adjusted to any standard. Invented by exhibitor in 1848.

William Sykes Ward.

1444. Galvanometer, designed by **Colladon** for **Currents** produced by **Electro-Statical Charges.**

Geneva Association for the Construction of Scientific Instruments.

Apparatus for demonstrating that the electricity drawn from friction machines, from the clouds, &c., produces currents, of which the direction and the intensity are measured by the deviation of the magnetic needle of a galvanometer.

1445. Marine Galvanometers used on board H.M.S. "Agamemnon" and the U.S. Frigate "Niagara," in the Atlantic Cable Expeditions of 1858. *Sir William Thomson.*

A light mirror, weighing 30 milligrammes and 9 millimetres in diameter, with single needle cemented to its back, suspended by stretched platinum wire in centre of field of coil composed of two bobbins of fine copper wire. Micrometer screws to adjust zero by torsion of upper and lower parts of platinum wire. The first words transmitted across the Atlantic were from the "Agamemnon" approaching the Irish coast, and were read on one of these instruments on board the "Niagara" approaching Newfoundland. (Encyclopædia Britannica, Art. Telegraph (Electric), VII. 6, and VIII. 4.) Made by White and Barr (now James White), Glasgow.

This instrument was sent out for use on the first Red Sea cable (1859), but did not arrive until after the failure of the cable. It returned dismantled, and was never set in action again. It has been superseded by the siphon recorder. Made by White and Barr (now James White), Glasgow.

1446a. One of the First Mirror Galvanometers, made for the reading of messages through submarine cables, and used for that purpose at Newfoundland in 1858. This galvanometer has an arrangement for altering the intensity and direction of the directing force by a double motion of the directing magnet,—one varying its distance from the suspended needle and mirror, the other giving the magnet a motion in azimuth. This arrangement is still used in the Astatic Mirror Galvanometer for testing submarine cables. *Sir William Thomson.*

1447. Ironclad Marine Galvanometer, used on board the "Great Eastern" in the Atlantic Cable Expedition of 1866, and subsequently by Mr. Willoughby Smith in the Mediterranean and Red Sea. *Sir William Thomson.*

This instrument is the first ironclad marine galvanometer, and the first with suspension by stretched silk fibre instead of platinum wire. Made by James White, Glasgow.

1447a. Differential Galvanometer, constructed specially for testing the locality and nature of faults in submarine cables. It is the first instrument in which *shunts* were used for practical electrometric purposes. A shunt is applied to one of the wires of the coil so as to multiply the reading of a rheostat *ten* times. It also was used for telegraphic reading purposes and for measuring the discharge from cables. It was made in 1858, and was in constant use for many years. *W. H. Preece.*

1447b. Thomson's Mirror Galvanometer, with hinged coils, and **Shunt** for same. *Warden, Muirhead, and Clark.*

1447a. Sir William Thomson's Astatic Mirror Galvanometer, with hinged coils, for testing purposes. *Warden, Muirhead, and Clark.*

1447b. Lamp for Mirror Galvanometer. *Warden, Muirhead, and Clark.*

1447c. Portable Testing Galvanometer on gimbals, with resistance coils and shunts. *Warden, Muirhead, and Clark.*

1447d. Sir William Thomson's Dead-beat Mirror "Speaking" Galvanometer for receiving signals on long submarine cables, provided with scale, stand, and lens. The mirror carrying the magnets is confined in a small air-chamber which can be contracted at will. The compressed air acts like a cushion, and "damps" the motion of the mirror, thereby preventing oscillations. *Warden, Muirhead, and Clark.*

1448. Absolute Galvanometer or Magnetic Dynamometer. *Frederick Guthrie.*

A current traverses in succession four spirals embracing soft iron cores. Two of the so formed electro-magnets are fixed and two movable together in a horizontal plane by means of the suspending torsion thread. The spirals are such that the magnets repel one another. If, when no current is passing, a beam of light reflected from a mirror attached to the movable pair falls in a certain place, then, when a current passes, the torsion screw head must be turned so as to force the magnets up to the same distance as before. The repulsion or angular torsion is proportional to the square of the strength of the current.

1449. Galvanometer for measuring large currents in definite units. Graduated in Weber units for use with the electric light, &c., and in ounces of silver deposited per hour, for use in electroplating and other forms of actual work. *John T. Sprague.*

1450. Patent Universal Galvanometer, indicating current and resistance in definite units of measurement.

John T. Sprague.

This galvanometer contains four circuits, having 1, 10, 100, and 1,000 fold degrees of action on the needle, enabling it to be used for large or small currents. The patent dial is graduated to indicate the current in actual units, either the British Association, Weber, or in chemical equivalents. It is also graduated to show the total resistance of the circuit in ohms without the aid of a resistance instrument when used with a Daniell cell. By using a fixed resistance it shows the electromotive force of the circuit in volts.

1450a. Galvanometer for Projections.

M. J. Duboscq, Paris.

1450b. Galvanometer, for thermo-electric currents.

Luzard, Paris.

1451. Rhé Electrometer of Marianini, for observing electric discharges between the atmosphere and the earth.

Robert James Mann, M.D.

This instrument was planned by Professor Melsens. It contains a coil of copper wire which is to be made continuous with the system of a lightning rod, or with the earth wire of a telegraph line. When an electric spark passes through the coil a soft iron bar in its interior is magnetised, and a traversing magnetic needle pivoted above the coil is then deflected by it out of the north and south line of the earth's magnetism towards either the east or west. When the interior iron has been magnetised it must be replaced by a neutral bar before another observation can be made.

1452. M. Becquerel's Electro-magnetic Balance. *Conservatoire des Arts et Métiers, Paris.*

1453. Pouillet's First Compass for Sines and Tangents. *Conservatoire des Arts et Métiers, Paris.*

1454. Sine-Tangent Galvanometer, for use at will either as a sine or tangent galvanometer. *Siemens and Halske, Berlin.*

1455. Aperiodic Galvanometer, with telescope and scale. *Siemens and Halske, Berlin.*

The needle of this galvanometer is suspended in a copper ball, which acts as a damper, preventing vibration in any new position given to the needle. The needle itself is in the shape of a thimble cut away longitudinally on opposite sides, and by this arrangement the magnetic intensity is considerably increased, and the inertia of the magnet reduced. Du Bois-Raymond has shown that the "damping" of an astatic needle can be carried so far that the needle does not vibrate, but directly takes up its position of deflection, and these he has termed "aperiodically vibrating needles." Dr. Werner Siemens has attained the same end with simple non-astatic magnets, by means of certain forms of the vibrating magnets, and of the damping copper mass. The vibrating magnet consists of a steel thimble, from which two opposite sides are cut away parallel to the axis. This horseshoe magnet vibrates in a cylindrical space in a copper ball, which forms the centre of the wire coils.

1456. Inclination Galvanometer. *Dr. Werner Siemens.*

Intended for use particularly with the selenium photometer (No. 895). The coil of the galvanometer is wound horizontally; the needle vibrates in a vertical plane and carries a mirror which reflects the image of a finely photographed scale (placed above) into the optical axis of a microscope.

1457. Galvanometer for testing Lightning Conductors, constructed by the exhibitors for the Prussian Royal Engineers. *Keiser and Schmidt, Berlin.*

1458. Mirror Multiplier. *E. Stöhrer, Leipzig.*

1459. Galvanometer, showing both inclination and declination. *E. Stöhrer, Leipzig.*

The broad brass frame which carries the magnetic needle can be turned about its axis; likewise the vertical support in its base. Thus the needle can be enabled to move in various planes, and the altered action of the force measured by observation of the vibrations.

1459a. Current Measurer, with arrangement for very strong electric currents. *Gustav Baur, Stuttgart.*

1460. Edelmann's Mirror-galvanometer for absolute measurements. *M. Th. Edelmann, Munich.*

1461. Large Wiedemann's Galvanometer. *M. Th. Edelmann, Munich.*

1462. Small Wiedemann's Galvanometer. *M. Th. Edelmann, Munich.*

1463. Edelmann's Compensation-galvanometer. *M. Th. Edelmann, Munich.*

1464. Edelmann's Lecture-galvanometer. *M. Th. Edelmann, Munich.*

1465. Edelmann's Small Mirror-galvanometer. *M. Th. Edelmann, Munich.*

1466. Edelmann's Pocket Compasses, with absolute measurements for electro-therapeutics. *M. Th. Edelmann, Munich.*

1467. Du Bois-Raymond's Astatizing Magnet. *M. Th. Edelmann, Munich.*

1468. Ordinary Compensator. *M. Th. Edelmann, Munich.*

1469. Edelmann's Induction Galvanoscope. *M. Th. Edelmann, Munich.*

1470. Large Galvanometer for **Electro-therapeutic Purposes.** *M. Th. Edelmann, Munich.*

1471. Differential Galvanometer, very delicate, with two coils. (Becker, London.) *H. Lloyd, Trinity College, Dublin.*

1474. Apparatus to illustrate some of the laws of electrical rotation of Faraday and Ampère. *Yeates & Sons.*

1475. Tangent Galvanometer. *James How & Co.*

1476. Thomson's Astatic Reflecting Galvanometer, round glass case, for lecture purposes. *Elliott Brothers.*

The most sensitive instrument yet constructed for detecting the presence of a current and measuring its magnitude.

1477. Thomson's Astatic Reflecting Galvanometer, in square brass case, made by Elliott Brothers. *Prof. W. F. Barrett.*

The upper coil of this galvanometer has a very high resistance, the lower a very low one; the coils are used independently, but require only one lamp, and hence can readily be changed without any disturbance by merely changing the position of the plug.

1478. Set of Shunts, for use with galvanometers, to reduce the angle of deflections of the needle 10, 100, or 1,000 times by shunting off the current, so that only $\frac{1}{10}$, $\frac{1}{100}$, or $\frac{1}{1000}$ of the current passes through the galvanometer, and the remainder through the shunts. *Elliott Brothers.*

1479. Simple Horizontal Galvanometer, coiled with stout wire of low resistance, intended especially to show thermo-electric currents. *Elliott Brothers.*

1480. Tangent Galvanometer, designed by Gaugain, for measuring electro-motive force, resistance, &c. *Elliott Brothers.*

The instrument is composed of two coils, separated by a distance equal to one half their diameter; contains three sections of stout wire, which can be connected at pleasure. This instrument can be used with very powerful currents.

1481. Speaking Galvanometer, used for signalling through submarine cables. The mirror and magnet are doubly suspended; glass in front and back protect the mirror and magnet from draught and dust. *Elliott Brothers.*

1482. Oil Vessel Galvanometer, as used in military schools, for testing and signalling. *Elliott Brothers.*

The coils consist of two sections of high and low resistance, which can easily be brought into circuit by a switch in front of the instrument. To reduce the oscillations of the needle, the instrument is provided with a glass vessel for liquids, into which the vane of the needle dips.

c. ELECTRO-DYNAMOMETERS.

1472. Electro-Dynamometer. Apparatus for the determination of the strength of electric currents by measuring the action between different parts of the current itself.
H. Lloyd, Trinity College, Dublin.

1483. Electro-dynamometer, for measuring electric currents which are constantly being reversed in direction. Made by Dr. Meyerstein, of Göttingen. *George Gore, F.R.S.*

1484. Edelmann's Absolute Dynamometer,
M. Th. Edelmann, Munich.

1485. Fine-wire Electro-dynamometer.
M. Th. Edelmann, Munich.

d. VOLTAMETERS.

1486. Voltameter.
Geneva Association for the Construction of Scientific Instruments.

The tube of the voltameter is divided on glass into sixteenths of cubic centimetres.

1486a. Voltameter for teaching purposes.
Physical Institute (Univ. of Giessen), Dr. Buff.

This apparatus for the decomposition of water is described in Liebig's Annalen, Vol. 93, p. 256. It is intended to render the gases evolved available for analysis or otherwise.

The connecting piece, fitted above with caoutchouc tubing, serves for ordinary purposes. By means of the apparatus, not only may the reconstitution of water be shown, but the phenomena of heating and ignition, *e.g.*, of a steel spring. For such experiments 12 Bunsen pairs are necessary, connected in series.

1486b. Silver Voltameter, with platinum vessel.
Prof. Beetz, München.

A convenient modification of the Poggendorff voltameter.

1486c. Mercury Voltameter.
The Physical Science Laboratory of the Technological Institute, St. Petersburg (Russia).

This apparatus is intended for measuring the strength of currents by the reduction of mercury. It consists of two electrolytic glass bowls joined by a tube, and an apparatus for measuring the reduced mercury volumetrically. A more detailed description, with drawing and directions for use, accompany the instrument.

1732b. Electrotype Apparatus, with stand, and Poggendorff's silver voltameter. *Prof. Hittorf, Münster.*

The vessels serve in investigating the processes by which the electrolytes in aqueous, alcoholic, or other solutions afford passage to the electric current. They enable the changes occurring in the electrodes to be kept distinct and fully determined by quantitative chemical analysis. In soluble electrolytes the ions can be certainly determined, and so the primary decompositions distinguished from the secondary. Further, the apparatus shows the ratio of the velocities with which the two ions move in opposite directions. (*See* Poggendorf's Annalen, Bd. 89, 96, 103, and 106.)

IX.—APPARATUS FOR MEASURING ELECTRICAL RESISTANCE AND CAPACITY.

1487. Wheatstone's Bridge of the simplest construction, especially used for conductivity and low resistance tests. The bridge is provided with one pair of equal resistances and one standard resistance. *Elliott Brothers.*

1488. Thomson's Circular Sliding Resistance, of great importance in cable tests in connexion with the quadrant electrometer for measuring resistance, tension, or potential of cables and batteries, and for detecting faults in cables.
Elliott Brothers.

1488a. Megohm or 1 million Ohms resistance, valuable for measuring very high resistances, for determining the constants of galvanometers, &c. *Elliott Brothers.*

1487a. Revolving Coil used in the determination of the **"British Association Unit of Electrical Resistance,"** 1863–4. (The property of the British Association.)
Prof. Clerk Maxwell.

The coil forms a closed conducting circuit. As the coil revolves about a vertical axis, the horizontal component of the earth's magnetic intensity produces an alternating current in the coil. A very small magnet is suspended at the centre of the coil, and is deflected from the magnetic meridian by the current in the coil. When the coil revolves rapidly, the alternations of the current do not produce any sensible vibration of the magnet, and the tangent of the permanent deflection is a measure of the conductivity of the coil.

1487b. Resistance Coil in an annular brass case, and embedded in paraffin. The resistance of the revolving coil was compared with that of this coil during the experiments.
Prof. Clerk Maxwell.

1487c. Bridge Arrangement used in the above comparisons.
Prof. Clerk Maxwell.

1489. Plate, showing **Dr. Bosscha's Method** of determining the **Ratio of two resistances,** with explanatory note.
J. Bosscha, Professor, Royal Polytechnic School, Delft.

1490. Plate, showing **Dr. Bosscha's Method** of determining the **Ratio of two electro-motive forces,** with explanatory note.
J. Bosscha, Professor, Royal Polytechnic School, Delft.

1491. Cylindrical Condenser for measuring Capacity in absolute electrostatic units. *Sir W. Thomson.*

1492. Adjustable Disc Condenser, also used as a spark micrometer. *Sir W. Thomson.*

1492a. Early Rheostat, given by Faraday to Sir Charles Wheatstone. *The Council of King's College, London.*

1492b. Divided Condenser, as designed by Major Malcolm, R.E., for comparing the electrostatic capacities of cables, the electro-motive force of batteries, &c. *Elliott Brothers.*

This condenser is in 12 subdivisions, as follows, viz.:—·001, ·002, ·002, ·005, ·01, ·01, ·02, ·05, ·1, ·1, ·2, ·5 = 1 microfarad; so that any capacity from $\frac{1}{1000}$ to 1 microfarad can be obtained.

1493. Rheostat with large copper wire.
The Council of King's College, London.

1494. The Original Wheatstone's Bridge.
The Council of King's College, London.

1494a. Rheostat (Agometer), with platinum wire. Invented by M. H. Jacobi, in the year 1841.
Physical Science Cabinet of the Imperial Academy of Sciences, St. Petersburg.

1495. Universal Resistance-Box.
Siemens and Halske, Berlin.

This instrument is intended to measure by simple manipulation the resistance of wires, the electro-motive force of batteries, and their internal resistance. It has three branch resistances, and a complete series of resistances from 1 to 10,000 S. U.

1496. Complete Bridge. *Siemens and Halske, Berlin.*

This bridge, besides the branch resistances, and variable resistance, includes battery reverser, galvanometer key, and short circulating keys, so arranged that one of the branch resistances or the variable resistance can be cut out instantaneously.

1495a. Large Lane's Measuring Flask.
Warmbrunn, Quilitz, & Co., Berlin.

1497. Edelmann's Small Rheochord.
M. Th. Edelmann, Munich.

1498. Resistance Apparatus with Weber's absolute units.
M. Th. Edelmann, Munich.

1499. Universal Compensator, for measuring resistances and electro-motive forces. *Prof. Beetz, Munich.*

The apparatus exhibited by Prof. Beetz was manufactured from his plans by M. Th. Edelmann.

1499a. Compensator, by Fresnel, made by Froment.
Polytechnic School, Paris.

1500. Post Office Resistance Coil, as used by the Government telegraph authorities, for testing the resistance of telegraph lines, cables, batteries &c. *Elliott Brothers.*

These coils are constructed on the Wheatstone's bridge principle, and the arrangement allows of the measurement of resistances from $\frac{1}{100}$ to 1,000,000 ohms.

1501. Dial Resistance Coil, for testing the resistance of telegraph lines, cables, batteries, &c. *Elliott Brothers.*

These coils are capable of greater accuracy than other resistance coils. For each dial only one plug is used to bring the desired resistance in circuit, for every change, therefore, the same number of plugs is necessary.

1502. Preece's Balance, for comparing resistances in connexion with a set of resistance coils. *Elliott Brothers.*

This instrument is on the principle of the Wheatstone's bridge, and contains four pairs of equal resistances, a commutator, and two keys.

1503. Set of Resistance Coils, German silver, with Wheatstone's bridge, for testing the resistance of telegraph lines, cables, batteries, &c. These coils allow of measurements of resistance from $\frac{1}{100}$ to 1,000,000 ohms. *Elliott Brothers.*

1504. British Association Unit or Ohm, of German silver wire, equal to 10^7 absolute electro-magnetic units, the standard of electrical resistance. *Elliott Brothers.*

1504a. Large Set of Resistance Coils, with Bridge (a new form and arrangement). *Warden, Muirhead, and Clark.*

1504a. Large size set of Resistance Coils, containing a resistance of 11,110 ohms in the aggregate, with proportional coils of 10, 100, 1,000, and 10,000 ohms. The units, tens, hundreds, and thousands are in separate sets; the resistances are thrown into circuit by inserting the plugs.
Warden, Muirhead, and Clark.

1504aa. Medium size set of Resistance Coils, with proportional coils of 10, 100, 1,000 ohms.
Warden, Muirhead, and Clark.

1504cc. Small set of Resistance Coils.
Warden, Muirhead, and Clark.

1504cd. Set of Proportional Coils, containing three pairs of 10, 100, 1,000 ohms respectively. To be used with 1504cc.
Warden, Muirhead, and Clark.

1504ce. Set of Standard Resistance Coils, 10, 100, 1,000 ohms. *Warden, Muirhead, and Clark.*

1504cf. Set of Galvanometer Shunts, $\frac{1}{9}$, $\frac{1}{99}$, $\frac{1}{999}$, $\frac{1}{9999}$ of the resistance of the galvanometer.
Warden, Muirhead, and Clark.

1504b. New combined Set of Thomson and Varley's Resistance Slides (a new form and arrangement).
Warden, Muirhead, and Clark.

1504c. Set of Resistance Coils (small portable set), containing 10,000 B A units in the aggregate, and set of proportional coils for same. *Warden, Muirhead, and Clark.*

1504d. Condenser, 20 microfarads.
Warden, Muirhead, and Clark.

1504e. Small portable Standard Condenser, capacity 1 microfarad in aggregate, divided in : 1 : 2 : 3 : 4 microfarads.
Warden, Muirhead, and Clark.

1504f. Standard Condenser, $\frac{1}{3}$ microfarad.
Warden, Muirhead, and Clark.

1504d. Condenser or Accumulator of 20 microfarads capacity. This form is principally used in telegraphing through long submarine cables. It is placed between the cable and the receiving instrument, or between the latter and the earth in order to render the signals more distinct.

Warden, Muirhead, and Clark.

1504f. Standard Condenser of 5 microfarads capacity subdivided into tenths. *Warden, Muirhead, and Clark.*

1504g. Standard Condenser of 5 microfarads capacity. *Warden, Muirhead, and Clark.*

1504g. Sine Inductor. Apparatus for producing an induction current by the rotation of a magnetic disc for determining resistance. *L. Waibler, Darmstadt.*

1507. Conductivity Apparatus, for comparing the conductivity of wires of copper, or any other metal or alloy, with 100 inches of pure copper weighing 100 grains, 200 inches weighing 100 grains, or 300 inches weighing 100 grains. The conductivity is determined by resistance, length, and weight.

Elliott Brothers.

X.—STANDARDS OF COMPARISON FOR MEASUREMENT OF ELECTRICAL MAGNITUDES.

1505. Weber's Resistance Coils, No. 3 and No. 5, certified to represent the following resistances:—

No. $3 = 60717 \times 10^5$ Weber's absolute units.
No. $5 = 59440 \times 10^5$ „ „

J. Bosscha, Professor, Royal Polytechnic School, Delft.

Comparisons of these coils were published by Dr. Schröder van der Kolk in Poggendorff's Annalen, vol. 110, p. 465.

The coil No. 3 was used in the first determination of the electro-motive force of a Daniell's cell in absolute measure, executed in 1857 by Dr. Bosscha. This electro-motive force was found to be 1026×10^8 Weber's absolute units. Applying Sir William Thomson's theorem (Phil. Mag., Series IV., vol. ii. p. 557), the mechanical equivalent of heat derived from this result is 432·1 as compared with MM. Favre and Silbermann's determination of the heat generated by the action of zinc on sulphate of copper; 419·5 as compared with Mr. Joule's experiments on the heating power of a Daniell's cell (Phil. Mag., Series IV., vol. iii.), discussed in Poggendorff's Annalen, vol. 103; 437·3 as compared with similar experiments of Professor Lenz (Pogg. Ann., vol. 59, p. 203), discussed in Poggendorff's Annalen, vol. 108, p. 162; and 421·1 as compared with similar experiments of Mr. Joule, related in "Memoirs of the Lit. and Phil. Soc. at Manchester," vol. vii. p. 94, and discussed in Poggendorff's Annalen, vol. 108, p. 168.

1506. Siemens' Resistance-Unit.

Siemens and Halske, Berlin.

This is a wire resistance equivalent to the resistance offered by a prism of pure mercury one square millimetre in section and one metre long at 0° centigrade, which is the basis of the Siemens' standard unit.

1506a. Normal Mercury Unit in glass spiral.
Siemens and Halske, Berlin.

1504g. Clark's Standard Element.
Warden, Muirhead, and Clark.

This is the most constant voltaic cell known as regards electro-motive force. It is used as a practical standard of electro-motive force. The poles are pure zinc and mercury. The exciting paste is composed of protosulphate of mercury boiled in a saturated solution of sulphate of zinc.

XI.—APPARATUS FOR THE APPLICATION OF ELECTRICAL PRINCIPLES TO PRACTICAL PURPOSES.

a. Telegraphic Apparatus.

1652. Electric Telegraph, original apparatus as it was made under the direction of its original discoverer, Th. Sömmering, in München, 1809. *K. Sömmering, Frankfort.*

1653. The Volta's Pile, then used for the above, together with the 10 original silver, and 10 original zinc plates.
K. Sömmering, Frankfort.

1654. The Original Conducting Wire, as it was made under the direction of the discoverer in 1809–1811, and tested in the Isar. *K. Sömmering, Frankfort.*

1655. Alarum belonging to Sömmering's Telegraph.
K. Sömmering, Frankfort.

1508c. Portion of the **original Telegraph,** laid by Sir Francis Ronalds in 1816, in his garden at Hammersmith, and described in his book in 1823. *Latimer Clark, Westminster.*

The original wooden model of the dial of the instrument used with the above telegraph.

1508aa. Electric Telegraph. A portion of the original copper wire and glass tube buried by Sir Francis Ronalds in 1816 for the purpose of his then new discovery of electric telegraphy; found after several months' search by the exhibitor in 1862.
Captain Henry Hill.

1508aa. Two Drawings illustrating plans by Sir Charles Wheatstone, in 1840, for the manufacture of submarine electric telegraph cables, and proposed plans for laying the same.
Sir Charles Wheatstone.

1680a. First Electro-magnetic Needle Telegraph, invented in the year 1830 by Baron P. L. Schilling (born in 1786 at Reval), consisting of:—

Two electro-magnetic alarum apparatus; two ditto, and gyrotropes (key-board, indicator); one current indicator; one multiplicator for the signs (sign receiver) of the magnetic needle to the right or to the left respectively, turning of the white or black side of a paper disc towards the spectator.

Physical Science Cabinet of the Imperial Academy of Sciences, St. Petersburg.

1508b. Portion of the **first line of Telegraph,** laid by Cooke and Wheatstone in 1837 between Euston and Camden stations. It consists of five wires and was worked with their earliest or "hatchment" dial instrument. *Latimer Clark.*

1419. Part of **Cooke** and **Wheatstone's First Working Telegraph.** *Edinburgh Museum of Science and Art.*

1680. Specimen of the First Telegraph Line, 1837. *R. S. Culley.*

This specimen of the first Telegraph line was dug up on the railway incline between Euston and Camden. It was laid down in connexion with the first experiments made with Cooke and Wheatstone's earliest instrument in 1837.

1689. Cooke and Wheatstone's A B C Instrument, 1840. *Reid Brothers, London.*

The escapement wheel on the axle of which the pointer is fixed is controlled by electro-magnets.

The communicator is outside, and concentric with the indicator dial, and consists of a cog-wheel working into two smaller wheels. The cog-wheel is turned by a handle, and the battery contacts are made by small wooden cylinders inlaid with metal fixed on the smaller wheels.

The wheelwork is driven by a mainspring.

1690. Nott and Gamble's Step by Step Pointer Telegraph, 1846. *Reid Brothers, London.*

Electro-magnets act on a ratchet-wheel by means of clicks attached to their armatures. On the axle of the ratchet-wheel the pointer is fixed; the latter is moved forward through a space equal to the distance between two letters for each making and breaking of the battery contact. A simple tapper or pedal key is used for sending the currents, and the pointer is allowed to rest for a short interval when it is opposite to the letter desired to be indicated. The instrument is furnished with an alarum, the bell being struck by a hammer attached to the armature of an electro-magnet provided for the purpose.

1681. Cooke and Wheatstone's Double-Needle Telegraph, with Alarum. Earliest form, with 6-inch coils and astatic needles. *Reid Brothers, London.*

These instruments were used on the line erected between Paddington and Slough for the purpose of exhibiting the invention in 1844, and were the identical instruments by the aid of which Tawell was caught.

1682. Double-Needle Instrument. As used by the Electric Telegraph Company in 1846. *Reid Brothers, London.*

Used for all public business, and for the principal railway circuits, with 6-inch coils and astatic needles. The coils were afterwards reduced to one inch. The double needle was superseded for public purposes by the Bain recording instrument from about 1850. It is still used by some railway companies.

1683. Cooke and Wheatstone's Single-Needle Instrument. (Early form.) *J. A. Warwick.*

Used by the Electric Telegraph Company in 1846 on unimportant railway circuits.

The specimen exhibited has a "crutch" handle commutator, which was the earliest form used; later the "drop" handle was introduced.

1508d. Two Photographs of the **Telegraph Apparatus** used by **Gauss and Weber.**

Physical Institute of the University of Göttingen (Prof. Dr. Riecke).

One of the photographs represents the magnetic inductor which serves for giving the signals, the other the unifilar magnetic rod with multiplier serving for receiving the signals.

1508. Two Original Drawings of plans, sections, and elevations of machinery of Sir C. Wheatstone's proposed scheme for a sub-marine telegraph cable, 1840. *Robert Sabine.*

1508a. Portion of the **First Submarine Telegraphic Cable.** This cable was laid by Mr. T. R. Crampton, C.E., in 1851, and established the practicability of submarine telegraphy. *Thomas Russell Crampton.*

Submarine telegraphy in 1851 was deemed by most engineers and the public to be visionary if not impracticable.

Its extension over the whole world since its first practical introduction in 1851, has been immense, and its advantages incalculable. It was established in the following manner:—Various propositions were from time to time put forth to effect the object, but few people were prepared to take the risk until a company was formed having most influential men on the direction, who advertised in the usual manner for subscriptions. Such, however, was the want of confidence felt in the scheme, that only about two per cent. of the necessary capital was subscribed, and this money was consequently returned to the applicants. Notwithstanding this apathy of the public some of the directors and their friends did not cease to entertain a full conviction of its possibility, and they subsequently consulted Mr. T. R. Crampton, C.E., on the subject, and offered to assist towards providing the funds if he felt sufficiently confident of ultimate success. Mr. Crampton undertook the entire charge and responsibility of the form, construction, and laying of the cable, and also took upon himself rather more than one half the pecuniary risk, the other half of the money being found by Lord de Mauley, Sir James Carmichael, Bart., Messrs. Davies Son and Campbell (the solicitors of the Company), the Hon. F. W. Cadogan, and Mr. Haddon.

The cable was in the same year (1851) successfully laid between Dover and Calais by Mr. Crampton.

The great risk the parties ran can be better appreciated from the fact that three successive attempts by other parties to establish submarine cables between England and Ireland occurred soon afterwards, which all failed.

The above-named gentlemen were also instrumental in laying the next successful cable between Dover and Ostend.

This latter was constructed in a similar manner to the original one, and they are both still in operation.

No fundamental change has yet been effected in the form and mode of construction of heavy cables, thus proving satisfactorily that the first type of heavy submarine cable laid upwards of twenty-five years ago is practically right in principle.

1508f. Magneto-Electric Machine termed a **"Thunder Pump."** *Reid Bros.*

1508g. Cooke and Wheatstone's Coil, 1837, with front and back needle ; coil wound with cotton covered wire.
Reid Bros.

1508h. Reid's Patent Circular Coil, 1848, with front and back needle complete ; coil wound with cotton covered wire.
Reid Bros.

1446. First Instrument for **recording Signals** through **Long Submarine Cables,** by curve of perforations produced by sparks from a Ruhmkorff coil guided by a platinum wire moved by a needle under the influence of the varying current from the cable. *Sir William Thomson.*

SPECIAL COLLECTIONS ILLUSTRATING THE HISTORY OF ELECTRIC TELEGRAPHY, CONTRIBUTED BY H.M. POSTMASTER GENERAL.

1508e. Cooke and Wheatstone's Earliest Needle Telegraph, 1837.

The letters are indicated by the convergence of two needles. The five line-wires required for the instrument were inserted in grooves in a triangular piece of wood, and wire laid underground.

1509. Cooke and Wheatstone's Four-Needle Telegraph, 1838.

Some of the letters are indicated by the convergence of two needles, as in the five-needle instrument, the rest by one or more movements of the needles to the right or left.

1548. Cooke and Wheatstone's Revolving Disc Telegraph, 1840.

A step-by-step instrument. The letters of the alphabet are arranged round a paper disc fixed on the axle of an escapement wheel.

The letters are presented at an opening in the front of the case.

The escapement is similar to the "échappement-à-cheville," and is *controlled* by an electro-magnet.

There are as many teeth in the escapement wheel as there are letters on the revolving disc; the latter moves from one letter to the following for each current sent.

The train of wheelwork is actuated by a mainspring.

1549. Cooke and Wheatstone's Pointer Telegraph Instrument, 1840.

This instrument is similar in all respects to the revolving disc telegraph, excepting that a pointer takes the place of the revolving disc.

1550. Cooke and Wheatstone's Magneto-Electric Communicator, used with their revolving disc or pointer alphabetical telegraph, 1840.

This communicator is so arranged that a current is sent when its spoked wheel is turned through a distance equal to that dividing the letters engraved upon it.

The commutator fixed on the axle of the revolving electro-magnet is so constructed that the magneto-electric currents are all in the same direction.

1516. Old Form of Double-Needle Instrument, with six-inch coils.

1512. Double-Needle Instrument, newer form.

Used by the Electric Telegraph Company.

1514. Portable Double-Needle Instrument, which can also be used for testing wires.

Each of the needles worked by two finger keys behind the case.

1515. Model Double-Needle Instrument with a Key Commutator, 1849.

1511. Single-Needle Instrument, modern form, with handle commutator.

Used by the Electric Telegraph Company and by railways.

1517. Series, showing the several Forms **of Coil and Needle** used by the Electric Telegraph Company.

a. The original form. 6-inch coils.
b. Holmes' diamond needle. 1-inch, 1848.
c. Clark's Needle.
d. S. A. Varley's coil with soft iron needle magnetised by induction.
e. Spagnoletti's do.
f. Brittan's do.

1518. Early Train Signalling Instruments.

a. Cooke's first "block" instrument used on the Norfolk Railway, about 1845.
b. Step by step train indicator used on the London and South-western Railway.
c. Do. do. South-eastern Railway.
d. Signalling instrument used for starting and stopping the endless rope by which the Blackwall Railway was first worked, about 1840.

1510. Alarum with Centrifugal Hammer. Used in connexion with Cooke and Wheatstone's first needle instruments.

Moved by wheelwork and mainspring; released by an electro-magnet. Used in connexion with Cooke and Wheatstone's first needle instruments.

1513. "Thunder Pump."

Henley's Magneto-Electric Machine, used for ringing alarums, etc., commonly known as the "Thunder Pump." Used by the Electric Telegraph Company.

1554. Early form of Wheatstone's Resistance Coils.

1552. Bain's Chemical Telegraph. (**Incomplete.**) **First form of recording Instrument used in England,** 1846.

The chemically-prepared paper is wrapped round the cylinder. An iron style presses on the paper and writes dots and dashes in a spiral line as the cylinder moves endwise while revolving.

The signals are formed manually by pressing a key, or automatically by a spring, making contact through perforations previously punched in a paper ribbon.

1551. Bain's Perforator for double dot or Steinheil Alphabet, 1846.

The perforations are made by circular punches on a band of paper. The third key on the right is for advancing the paper without punching, for spacing between letters and words.

1532. Bain's Chemical Telegraph as used by the Electric Telegraph Company in 1850 in place of the double needle.

The paper ribbon was prepared with yellow prussiate of potash and nitrate of ammonia; the style is of iron. The Steinheil code, dots in two parallel lines, was occasionally used, but was entirely superseded by the Morse code of dots and dashes.

1531. Morse Embosser, about 1853. Used by the Electric Telegraph Company.

This superseded the Bain instrument and was in its turn superseded by the inkwriter.

The dots and dashes of the Morse alphabet are made by a rounded steel point fixed at one end of a lever, the other end being furnished with an armature and attracted by an electro-magnet worked by a relay and loca battery.

1533. Various forms of Ink-writers. (Old.)

a. Breguet's ink-writers.
b. Ink-writer with inking pad and reservoir.
c. Do. do. ink bottle.

1529. Keys used with the Bain and Morse Telegraphs, by the Electric Telegraph Company.

a. Simple spring key.

b. Key for sending a short reversal after each signal, two sets of batteries being required. When the key is up, the line wire is connected to the receiving apparatus.

c. Wheel key. A constant current is maintained on the line, and signals are made by depressing the key and thus reversing the current. A switch is used for making the necessary alterations to the connexions for sending and receiving.

1528. Plunger Signalling Key, used by the London District Telegraph Company.

This key is used instead of the drop handle key of Cooke and Wheatstone's instrument, or the two-pedal key in Highton's instrument. An ordinary single-needle indicator is used in connexion with it.

1538. Whitehouse's Relay, 1854.

A small permanent horseshoe magnet oscillates between the pole pieces of an electro-magnet. The adjustment is effected by the attraction of another small permanent magnet.

1534. Varley's Mill, 1855. Used by Electric Telegraph Company.

This contrivance was used in connexion with relays and translators. When a current passes through the coils the armature is attracted rapidly in the usual way, but when the current ceases the armature returns slowly to its normal position, by the intervention of a wheel, pinion, and fly, thus lengthening the contact between the line lever and the spacing battery. This is now effected by utilising the extra current from the magnet. (*See* 1566.)

1535. Andrews' "Pump Relay" or "Spacer," used by the United Kingdom Telegraph Company.

This is a contrivance to produce a similar result to Varley's mill. A loosely fitting piston with a ball valve moving in a cylinder filled with oil is used instead of the fly.

1536. Zinc Sender, used by Electric Telegraph Company.

Used for sending a short reversal after each signal in the Morse system, to assist in discharging the line wire, in cases where the double-current key (1562) could not be used.

The coils of this apparatus are wound with fine wire of high resistance, and are placed as a "leak" or derived circuit on the line wire at the sending end. A single current Morse key is used. When this is depressed a portion of the current passes through the coils and moves the tongue of the relay over in contact with the screw stop which is connected to the reversing battery, the other pole of this battery being in connexion with the earth.

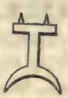
The back stop of the Morse key is in permanent electrical connexion with the tongue of the relay, and thus, when the key is raised and its lever comes into contact with the back stop, a reverse current will pass out to the line; but a portion of this reverse current also passing through the coils of the zinc sender will immediately move the tongue to the opposite side, the stop against which it rests being in connexion with the relay of the receiving apparatus. Thus after each reversal following a marking current the instrument is in a position for receiving, and the receiving station can stop the sending station during transmission. A smaller battery than the sending one is used for the reversal. A spring is fixed on the tongue on the battery side to lengthen the contact.

1539. Simple Electro-Magnetic Relay, used by the United Kingdom Telegraph Company. First form.

The simplest form of relay, consisting of an electro-magnet; its armature is attached to one end of a lever, the other end playing between two limiting stops, the local battery circuit being closed when the armature is attracted.

1540. Earliest Form of Relay with an inducing Magnet, used by the Electric Telegraph Company.

The coil is wound on a reel of soft iron, upon each end of which a hollow "casing" or cap of the same material is fitted, almost completely encasing the coil in soft iron. The armature is shaped thus, and is magnetised by induction from a compound bar magnet placed behind. The crescent-shaped portion plays between the inner ends of the casings, which for that purpose do not quite meet, but leave the central portion of the coil exposed.



An ordinary magnetic needle pivoted below the coil is acted upon by the latter, and serves as an indicator to call attention.

The armature is held up against knife-edge bearings by two helical springs, and the adjustment is effected by varying the tension of one of them.

1541. Later form of Relay, used by the Electric Telegraph Company, 1856. A few are still in use by the Post Office.

A horizontal bar of soft iron is pivoted vertically, and is free to move in the interior of two cylindrical bobbins. The ends of the bar which project beyond the bobbins play between the poles of horsehoe permanent magnets fixed at each end. The relay is adjusted by moving the stops, and consequently the soft iron bar, to one side or the other.

1519. Henley's Magneto-electric Double-Needle Instrument, 1848. Used by the British and Irish Magnetic Telegraph Company.

The needles only move on one side of their vertical position, and the signals are made up of the single and combined movements of the two needles.

This instrument requires two line wires, and is worked by the magneto-electric current generated by moving the handle or handles.

The interior needles are small straight bar magnets, playing between the semicircular pole pieces of an electro-magnet. The needle remains on the side on which it is left by the last current which passes through the coils, and does not return to its vertical position by gravity, as in Cooke and Wheatstone's needle instrument.

1520. Henley's Magneto-electric Single-Needle Instrument, 1848. Used by the British and Irish Magnetic Telegraph Company.

The dots and dashes of a modification of the Morse alphabet are represented by the duration of deflection of the needle on *one* side only of its normal position. It is worked by the magneto-electric current generated by moving the handle. Its construction is precisely similar in principle to Henley's magneto-electric double-needle instrument. It was used on less important lines than those on which the latter instrument was adopted.

1521. Highton's Needle Telegraph, 1848. Used by the British and Irish Magnetic Telegraph Company.

A horseshoe or circular magnet within a circular coil worked by a reversing key.

The signals are similar to those of Cooke and Wheatstone's single needle, but the alphabet is different.

Needle and coil used with this instrument.

1522. Highton's Needle Telegraph, smaller form. Used by the British and Irish Magnetic Telegraph Company.

Identical in construction with No. 1521, which it superseded.

1523. Highton's Needle Telegraph, last form. Used by the British and Irish Magnetic Telegraph Company.

With key detached. Identical in construction with the two former instruments, but the signalling key is detached from the indicating portion, and placed near the edge of the desk before the operator for greater convenience of working.

1524. Key, for Highton's single Needle Telegraph. Also used with Bright's Bell Instrument.

When the right-hand key is depressed a current in one direction is sent out to the line, and the pointer of the indicating instrument moves to the right. When the left-hand key is depressed a current in the opposite direction is sent, and the pointer moves to the left.

1525. Bright's Bell Telegraph, 1855, **with Relay.** Used by the British and Irish Magnetic Telegraph Company.

The single needle alphabet is produced by striking two bells of different tones, the hammers being actuated by electro-magnets worked by a relay and local battery. The relay consists of two electro-magnetic bobbins placed side by side, their ends being furnished with pole pieces turning inwards. Between these pole pieces at each end of the bobbins the ends of permanently magnetised needles pivoted on vertical axes play; these needles are so placed as regards their polarity, that a current in one direction moves the needle which closes the local circuit of the right-hand bell, and a current in the opposite direction moves the other needle which closes the local circuit of the left-hand bell. The signalling key used with this instrument is similar to that used with Highton's single needle.

1526. Bright's Direct Bell Instrument, 1870. (Model.)

Model of a Bright's bell instrument, in which the bells are struck by hammers attached to the magnetic needles of the relay.

1542. Relay for Bright's Bell Instrument.

A relay or repeater for relaying the signals of the Bright's Bell instrument used on the long lines of the British and Irish Magnetic Telegraph Company, when owing to leakage at the supports, from bad weather or other causes, the direct currents were too weak to work the whole length. In construction it is similar to the relay fixed on the bell instrument itself, but it consists of duplicate bobbins and magnetic needles.

1527. Highton's Gold Leaf Telegraph, 1846.

A movable conductor formed by a strip of gold leaf is placed in proximity to one pole of a permanent bar magnet, and moves to the right or left of its normal position according to the direction of the current passing through it. It was designed as a substitute for the needle and coil of Cooke and Wheatstone's instrument, but was never brought into practical use.

[This apparatus was described by Cumming in 1827, in his "Electrodynamics"; it is also mentioned in the *Encyclopædia Britannica*, 7th ed., Art. "Voltaic Electricity," and in the treatise on "Electromagnetism" in the *Library of Useful Knowledge*, 1832.]

1543. Wheatstone's Type Printing Instrument, 1841.

Steel type punches are fixed at the extremities of separate radiating springs placed round the circumference of a horizontal wheel, which is fixed on the quickest wheel of the train of wheel work, and governed by a dead beat escapement actuated by electro-magnets. The paper band passes under the type, and the printing is performed by an electro-magnet which causes a hammer to strike the proper punch when it is opposite the paper. Alternate layers of white and blackened paper are employed to receive the impressions of the punch.

1544. Theiler's Synchronous Type Printer, 1854.

Two currents are required for each letter, one to start the instrument and another to print. The type-wheel returns to zero after the printing of each letter.

1546. Theiler's "Step by Step" Type Printer, 1863–64.

The type-wheel fixed on the axle of the escapement is controlled by reversals, and the printing is performed by the wheelwork, which is brought into action by an electro-magnet, the local battery circuit of the latter being closed by a vibratory arrangement, which does not act until the type-wheel is stopped at the letter required.

1547. Dujardin's "Step by Step" Type Printer, 1865.

A step-by-step instrument in which the escapement of the type-wheel is controlled by reversals, the electro-magnets acting on the anchor of the escapement being worked by a polarised relay in the line circuit, and a local battery.

The operation of printing is performed by an electro-magnet, the local battery circuit of which is closed by the anchor of the escapement at the end of each oscillation.

When the apparatus is running, and no key is depressed, the currents passing through the printing magnet are too short to cause it to attract its armature; but when a key is depressed and the type-wheel stopped at any particular letter the duration of the current is lengthened, the printing magnet attracts its armature, and an impression is made.

An electro-magnetic "cut off" arrangement is used in connexion with the printing magnet, which causes the printing current to be equal in duration whether the key be held down for a longer or shorter time.

This instrument was used for a short period on a wire between London and Edinburgh in 1865, by the Electric Telegraph Company.

1545. Hughes' Type Printing Instrument.

This is a purely synchronous instrument. The instruments at each end of the line run at the same speed.

There are as many keys on the key-board as there are letters on the type-wheel, and the keys are so arranged that by pressing any one of them a current is sent to line at the moment the letter it represents on the type-wheel is opposite the printing hammer. The current actuates the printing hammer by releasing a detent in the wheel-work which drives the hammer.

There is a peculiarity in the electro-magnet which releases the detent. Its cores are polarised by a permanent magnet sufficiently strongly just to retain the armature in contact with its poles. The current overcomes this polarity and releases the armature, which is drawn away by a spring. It is replaced by the wheel-work connected with the hammer.

1537. Andrews' Relay, for Hughes' Type Printing Instrument, 1868, used by the United Kingdom Telegraph Company.

This relay is adapted for relaying the short currents required for working the Hughes' instrument; its peculiarity consists in the relayed currents being equal and independent of the line current.

Series of Apparatus for Recording the Steinheil or Single Needle Code.

The first recording telegraph was Steinheil's, completed in 1837. The code was formed of dots recorded in two lines, those in one of the lines being formed by the +, those in the other line by the − current. The code resembles that of Cooke and Wheatstone's single needle.

The system, if ever brought into practical use, was superseded by that of Morse, in which the code is comprised of marks of varying lengths.

But, as the dash occupies thrice the space and thrice the time of a dot, attempts have been made from time to time to introduce apparatus registering the Steinheil or single needle alphabet.

1564b. Unpolarised Recorder, for registering the single needle code.

1564c. Unpolarised Recorder, for registering the single needle code.

1564d. Polarised Recorder, for registering the single needle code.

1564e. Polarised Recorder, for registering the single needle code.

The negative current prints a *dot* (▪), the positive current *two dots* (⁚) transversely. The first represents the dot, the second the dash of the Morse alphabet. The letter A is written thus . . . . ▪⁚ .

1564f. Non-polarised Recorder, for registering the single needle code. Richard Herring's system.

The negative current prints a dot (▪), the positive current a transverse dash (▮), so that the printing resembles the Morse alphabet. The letter A is written thus ▪ ▮ .

1564g. Modification of Wheatstone's Automatic Transmitter, used in connexion with Richard Herring's system.

1564h. Modification of Wheatstone's Perforator, for his automatic system, arranged to punch the single needle code, used in connexion with Richard Herring's system.

Apparatus used by the Post Office in 1876.

1561. Wheatstone's A B C Instrument, Communicator, and Indicator.

This instrument is used on wires leased to private persons, and for the least important postal lines. It is well adapted for these purposes on account of not requiring skilled labour for its manipulation. The instrument is worked by a magneto-electric machine within the instrument.

Switches used with this instrument.
Alarum ,, ,,

1560. Single Needle Instrument.

Used on lines of a class superior to those on which Wheatstone's A B C is employed. It is but little liable to derangement, and requiring no adjustment is preferred to recording or acoustic apparatus for circuits of secondary importance.

1558. Siemens' Direct Writing Morse Inker, with Morse Signalling Key and Galvanometer.

This instrument is well known, being used in almost every country; its advantage over the Morse embosser consists in the greater legibility of the signals, which can be read in any light, and it requires much less power to work it. This form is used on lines of moderate length, where the direct line current is sufficient to actuate the electro-magnet without the assistance of a relay and local battery.

1559. Siemens' Local Ink-Writer.

Used in connexion with a relay and local battery on lines where the direct current is not sufficiently strong to actuate the direct ink-writer.

1565. Sounder.

This instrument is of American origin; it is used instead of the ink-writer on some of the lines of the Postal Telegraph Department, the dots and dashes of the Morse alphabet being read by sound from the clicking of the armature lever instead of from the paper band of the recording instrument; it possesses the advantage of not fatiguing the eye of the operator, and allows him perfect freedom for writing the message.

1562. Double Current Morse Key.

It can be arranged either to be worked as a single current Morse key, or to send double currents, as desired.

1564a. Double-current Key, with levers instead of the ordinary springs.

These keys send double currents or reversals. By the *marking* current the tongue of the distant relay is moved to the battery contact, by the reversed or *spacing* current it is brought back to its rest stop. This arrangement increases the range of adjustment, and as a current passes to line between the signals the effect of leakage from other wires is in great measure neutralised.

A switch, or a *zinc-sender* (1536), is required to alter the connexions when changing from sending to receiving.

1572. Siemens' Relay used with the ink-writer.

1563. Stroh's Polarised Relay, with Inducing Magnet.

This relay is similar in construction to the electrical portion of the Wheatstone "Receiver," No. 1557.

1564. New form of Non-polarised Relay.

This consists of two vertical electro-magnetic bobbins the cores of which are prolonged. Two soft iron needles are fixed on a vertical axle passing between the coils, one at the top and one at the bottom end of the axle. These needles are placed crosswise, so that when the cores are rendered magnetic the four poles of the bobbins tend to turn the needles on their vertical axis in the same direction. Two adjustments are provided, one the ordinary spring adjustment, the other for moving the needles nearer to or further from the poles.

This arrangement is much more sensitive than the old form of non-polarised relay with horseshoe electro-magnet and armature.

1566. Double Current Translator, used for relaying double current Morse signals.

The signals are relayed from the lever of the sounder, the latter being worked by a polarised relay in the line circuit. The necessary alterations to the connexions for restoring the apparatus to its normal condition when transmission in either direction has ceased is accomplished by an automatic switch called a "spacer," which consists of an electro-magnet, armature, lever, and stops. The local circuit of this magnet is closed by the relay which works the sounder when a marking current is sent, and by another relay placed in the line circuit when a spacing current is sent, so that the armature is continually held down while a station is sending.

The armature is prevented from rising during the short interval between the currents by a "shunt" placed across the terminals of the electro-magnet coil, which forms a path for the extra current direct when the local circuit is broken, and delays the demagnetisation of the iron core.

1567. Duplex Translator for relaying the signals on long circuits, worked on the duplex system.

This apparatus consists of two sets of duplex instruments combined.

1569. Testing-Box Galvanometer.

Used for testing wires; the requisite changes of connexions for receiving and sending currents are made by a peg switch in front of the instrument.

1530. Switches or Commutators for making Changes of Wires in Circuits.

a. Earliest switch for double needle, fixed at Normanton about 1857.
b. Tumbler switch.
c. Umschalter or Universal switch.

1555. Wheatstone's Automatic Telegraph, 1867. The Perforator for preparing the paper ribbon.

There are three punches. The centre punch perforates small holes in the centre of the ribbon, which form a rack by which the paper is carriedf orward in the *transmitter*. The centre lever acts on this punch only; the other two act upon the centre punch, but in addition perforate large holes for the Morse dot and dash.

They are struck either by a small mallet or by pistons actuated by compressed air.

1556. The Transmitter.

In Bain's and other automatic systems electrical contacts are made through the holes in the paper. In Wheatstone's the holes act like the *cards* of a jacquard loom, and *control* the movements of the mechanism by which the contacts are made.

The apparatus can be adjusted to produce signals in three ways.

(*a.*) By persistent currents, the *marking* current lasting during the whole time of the dot or dash; the *spacing* or reverse current filling up the intervals between them. It acts precisely in the same way as the double-current key. (1562.)

(*b.*) By *intermittent* currents, where a signal is commenced by a short *marking* current, and ended by an equally short *spacing* current; no current whatever being sent in the interval, the line being disconnected.

(*c.*) By *compensated* currents, where signals are commenced and ended as in (*b.*), but instead of the line being disconnected in the interval a large resistance is inserted, so that the last current sent continues to flow, but is weakened.

1557. Receiver, 1867. This is a very sensitive ink-writer.

The electrical portion consists of two vertical electro-magnetic bobbins, the iron cores of which are furnished with pole pieces. Two soft iron pieces or tongues are fixed on a vertical axle, and are magnetised by induction from a horseshoe magnet placed near them; they play between the pole pieces of the electro-magnet. The marking disc is in connexion with an arm attached to the vertical axle, and is pressed against or removed from the paper ribbon according as the current passes in one direction or the other through the coils. The tongues of the electro-magnets are set neutral, so that they remain on the one side or the other after the current which has moved them has ceased to act.

The speed of the wheelwork can be regulated at pleasure to suit the rapidity of the signals.

1568. Translator for relaying the signals of Wheatstone's transmitter. (Post Office, 1876.)

It is somewhat similar to the double-current translator (1566). It differs in that the currents are sent forward by the tongues of the line relays themselves, instead of by sounders in a local circuit. These tongues are set so as to have no bias on either side.

The automatic switch is similar in principle to 1566.

1570. Regulator Clock and Apparatus for the distribution of Greenwich time current at provincial stations.

The current is sent on the wires used for message traffic, and it is therefore necessary to shift them from the telegraph apparatus to the time apparatus. To ensure regularity, this must be done automatically by means of a clock.

The wire by which the signal is to be received from the central station, as well as the wires on which the time signal is to be distributed, are connected to the levers of an electro-magnetic switch (No. 1571).

About 20 seconds before 1.0 p.m. a local current sent from the clock actuates this switch, causing the levers to be shifted from the stops which are in connexion with the ordinary instruments to those connected with the relay which fires the gun. When the time current passes through the relay it closes a local circuit in which the gun fuze and the battery are included.

About 20 seconds after the time current has passed, the local current actuating the electro-magnetic switch is interrupted by the clock, and the levers of the switch to which the line wires are attached are again placed in connexion with their respective instruments.

The clock itself is corrected daily in the following way :—

It is kept at a slightly gaining rate, and is stopped automatically by a detent which acts on a pin projecting from the escape-wheel when the hands point to 1.0 p.m. The pendulum, however, continues swinging.

When the time-current is received the outgoing current from the time-relay passes through an electro-magnet inside the clock which liberates the detent.

The clock is so arranged that a second electro-magnetic switch may be actuated, and the time current distributed in a similar way at 10.0 a.m.

1571. Automatic Time-Switch for switching line-wires from their instruments and connecting them to the time-relay.

1573. Galvanometer for showing incoming time-current.

1574. Galvanometer for showing outgoing time-current.

1553. Early form of "Chronofer," or time-current sending apparatus, used in London about 1852. (Incomplete.)

1575. Lightning Protectors or Dischargers (various).

a. Varley's Lightning Protector (original form).
b. ,, ,,
c. ,, ,,
d. ,, ,,
e. ,, ,,
f. ,, ,,
g. ,, ,,
h. ,, ,,
i. ,, ,,
k. ,, ,, Varley's vacuum (modern form). Tube
l. ,, ,, protector, vacuum tubes in water-tight
m. ,, ,, compartment for outdoor use.
n. ,, ,, Latest form of fine wire protector, Post Office pattern, consisting of a metallic bobbin, electro-nickel plated, in connexion with the earth. It is wound with a fine wire covered with silk and passed through melted paraffin wax, the wire being placed in the line circuit. The metallic bobbin is carefully lacquered to secure insulation in damp situations.

1576. Insulators. Various.

Original ring insulator.
Cone insulator, original form (1845).
,, ,, later ,,
,, ,, form for replacing broken insulators.
Walker's double-cone insulator (brown).
,, ,, ,, (white).
Insulator (1847), in which the bolt by which the wire is suspended is insulated by mastic cement in the cavity at the top of the insulator.

Brown earthenware insulator, with zinc cap (1850).
Do., with groove for wire.
Do., glass instead of earthenware.
(1851) brown earthenware.
„ glass.
Clark's invert insulator, corrugated.
Varley's double-cup insulator, fitted.
Ditto, in separate parts, 1862.
Varley's No. 11 wire double-cup insulator.
Brown earthenware insulator called (Z).
Double shed invert compressed ware.
Single „ „ „
South Devon invert insulator (brown).
„ „ „ (white).
Andrews' invert with ebonite inner shed.
„ „ bolt tube „
„ „ bolt tube and shed.
Ebonite insulator, single shed.
Old form of shackle.
Bright's shackle.
Modern terminal insulator.

TELEGRAPHIC APPARATUS CONTRIBUTED BY THE IMPERIAL GERMAN TELEGRAPH DEPARTMENT.

1608. Copy of the Electro-chemical Telegraphic Apparatus of S. T. Sömmering, the first German telegraphic apparatus, constructed in 1809.

1609. Drawings of the Russian Councillor Schilling's (of Kannstadt) **Apparatus,** being the first needle telegraph (two sheets).

1610. Copy of the Electro-magnetic Telegraphic Apparatus of Gauss and Weber, of Göttingen, made and used from 1833 to 1838. It consists of—

(*a.*) The signal sender (by means of induced current).

(*b.*) The signal receiver (a magnetic rod with multiplying coil and mirror).

(*c.*) Telescope for reading off the deflexions of the magnet; with stand.

1611. Copy of the Electro-magnetic Telegraphic Apparatus of Steinheil, in München, 1837.

1612. Electro-Magnetic Indicator, combined with type-printing apparatus of Siemens, of Berlin, constructed in 1846. Patented in Prussia.

1613. Bell Machinery for Railways (Siemens), 1847.

1614. First Gutta-percha Press for covering conductors with insulating material without a seam. After Siemens' model, and constructed by Fonrobert and Bruckner. By machines after this model numerous subterranean lines in Germany and Russia were constructed from 1847 to 1851, and submarine lines are now made in the same manner.

1615. Plate Lightning Conductor, employed first by Siemens in 1848 between Eisenach and Frankfort.

1616. Double Style Apparatus, with writer in relief (Siemens).

Constructed by Siemens in 1853. The lines made by Siemens and Halske, the Warsaw-Petersburg, and other telegraph lines, were at first worked with apparatus of this system.

1617. Polarised Relay for the above. Oldest form without a steel magnet. The magnetic induction of the core and armature is effected by a branch current of the local battery. (Siemens, 1851.)

1618. Key for the Polarised Relay.

1619. Magneto-electric Current Generator, with 28 pairs of magnets.

1620. Dynamic Mine Exploder (Siemens, 1850).

1621. Polarised Relay for Double-style Apparatus, with steel magnets (Siemens, 1852).

1622. Hand-puncher for Self-acting Sender.

1623. Transmitter for Self-acting Sender.

1624. Receiver for Self-acting Sender (Morse with suspended magnets).

1625. Relay for Self-acting Sender (with suspended magnets).

Employed by Siemens in 1855 in the first experiments made to employ short alternating currents of equal duration for production of Morse writing with aid of a polarised relay.

1626. Mile Resistance, with movable steel lever; Siemens, 1854.

1626a. Mile Resistance.

1627. Original Colour-writer of John, Prague, 1854.

1628. Relay with suspended magnets and double coils for conversation. Frischen and Siemens, 1854. Patented in Prussia, with resistance scale divided according to miles of copper wire, 1″ diameter. As made by Siemens since 1848.

1629. Polarised Relay, with a horseshoe electro-magnet and steel armature. Siemens, 1855. This form is still in use.

1630. Induction Coil.

1631. Induction Key.

1632. Apparatus System for submarine conduction. Siemens. Constructed for the Red Sea Telegraph Cable.

1633. Back Current Discharger for submarine conduction. Siemens, 1857. Used first in the Red Sea.

1634. Colour-writer by Siemens. First construction. A small colour arm, fastened on a universal joint, dips into an open reservoir of adjustable level. Patented in England in 1862.

1635. Hair Needle Galvanoscope of Siemens, 1869.

GENERAL TELEGRAPH APPARATUS.

1576aa. Telegraph Apparatus, &c.

General Direction of Russian Telegraphs.

1. Atlas, containing details of the construction of the Central Telegraphic Office in St. Petersburg.
2. Lightning conductor, for cable.
3. Lightning conductor, for station.
4. Insulator, with double cup (large model), "Korniloff's."
5. Insulator, with double cup (small model), same make.
6. Insulator, with double cup (large model), "Bélotine's."
7. Insulator, with double cup (small model), same make.
8. An element, "Meidinger's."

1750a. Telegraphic Instruments.

Messrs. Siemens Brothers.

1. A B C telegraph instrument with finger keys (under glass cover to show working parts).

A magneto-electric instrument not requiring battery; used for house, private, and railway telegraphs.

2. A similar instrument in wooden case.
3. A B C telegraph instrument with handle movement, in round case, not requiring battery; used for house, private, and railway telegraphs.
4. A similar instrument in square case.
5. Standard ink recording telegraph instrument with self-starting and self-stopping arrangement; for terminal stations.
6. A similar instrument arranged for translation.
7. Portable telegraph sounder for military purposes (Major Malcolm's pattern), non-polarised.
8. Polarised circular relay with double contact.
9. Bi-polar relay with double contact under glass cover.
10. Portable condenser of $\frac{1}{2}$ microfarad capacity, with 2 terminals and short circuit peg.
11. Sub-divided condenser of 1, 2, 2, 5, 10, 10, microfarad capacity, with 4 spring pegs and one short circuit peg.
12. Sub-divided condenser of 10, 10, microfarad capacity, with 3 terminals and short circuit pegs.

13. Subdivided condenser of $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, microfarad capacity, with spring pegs and short circuit peg.

14. Sliding rheostat of 10,000 units resistance.

15. Sliding rheostat of 8,400 units resistance.

16. Sliding rheostat of 1,300 units resistance.

17. Resistance coil of 1,000 ohms.

18. Portable resistance bridge for electrical testing, with 3 pairs of proportional coils, viz., 10, 100, 1,000, 10, 100, 1,000, and a set of 16 coils of the aggregate resistance of 10,000 units. All the coils are of platinum-silver alloy. The apparatus also includes battery key, galvanometer key, and reversing commutator.

19. Plate lightning protector for telegraph stations. The line plate and earth plate are of brass, transversely grooved and mounted on marble slab.

20. Lightning protector for telegraph stations. A fine silk covered wire forms part of the line circuit, and is wound round a grooved copper cylinder which is to be placed in connexion with earth.

21. Tubular lightning protector for telegraph stations. The line tube and earth tube are transversely grooved.

22. Universal galvanometer (portable), which serves for the following purposes:—

1st. Measuring electrical resistances, the instrument being arranged as a bridge:

2nd. For comparing electromotive forces. Professor E. du Bois Reymond's modification of Poggendorff's compensation method being used:

3rd. For measuring the intensity of a current, the instrument being simply used as a sine galvanometer.

The instrument consists of a sensitive galvanometer which can be turned in a horizontal plane, combined with a resistance bridge (the wire of which bridge instead of being straight is stretched round part of a circle). The galvanometer has an astatic needle suspended by a cocoon fibre, and a flat bobbin frame wound with fine wire. The needle swings above a cardboard dial divided in degrees; as, however, when using the instrument the deflection of the needle is never read off, but the needle instead always brought to zero, two ivory limiting pins are placed at about 20 degrees on each side of zero.

The galvanometer is fixed on a graduated slate disc, round which the platinum wire is stretched. Underneath the slate disc three resistance coils of the value of 10, 100, and 1,000 Siemens' units are wound on a hollow wooden block which protrudes at one side; this projection carries terminals for the reception of the leading wires from the battery and unknown resistance. The adoption of three different resistance coils enables the measuring of large, as well as small resistances, with sufficient accuracy.

The whole instrument is mounted on a wooden disc which is supported by three levelling screws, so that it may be turned round its axle. On the same axle a lever is placed which bears at its end an upright arm, carrying a contact roller. This roller is pressed against the platinum wire round the edge of the slate disc by means of a spring acting on the upright arm, and forms the junction between the A and B resistance of a Wheatstone's bridge, which resistances are formed by the platinum wire on either side of the contact roller, one of the three resistance coils forming the third resistance of the bridge.

23. Sine galvanometer (portable). The magnetic needle moves on a steel point within the wire coil, and graduated segment inside a circular brass case which turns in a graduated circle.

24. Detector galvanometer (portable) with 3 coils.

25. Detector galvanometer with oscillating magnet

26. Differential galvanometer, constructed on the double shunt principle.

27. Sounder telegraph instrument with split armature.

28. Set of ink recording instruments for duplex telegraphy, according to the differential system.

29. Double current Morse key with automatic switch for sending and receiving position, to be used with a single battery.

30. Morse key for testing purposes.

31. Double current Morse key for testing purposes.

32. Double current Morse key for signalling.

33. Discharging key.

34. Magneto induction bell with inductor of 6 magnets, for signalling on railways, mines, inclines, &c. without the use of batteries.

35. Magneto induction bell, similar to the above.

36. Ditto ditto.

37. Magneto inductor of 6 magnets, without bell.

38. Dynamo-electric exploder for low tension (quantity) fuses, used for blasting and torpedo firing purposes.

This apparatus consists of an ordinary Siemens' armature, which is caused, by the turning of a handle, to revolve between the poles of an electro-magnet. The coils of the electro-magnet are in circuit with the wire of the armature, and the residual magnetism of the electro-magnet cores excites at first weak currents, which pass into the electro-magnet coils, increasing the magnetism of the core and inducing still stronger currents in the armature wire, to the limit of magnetic saturation of the iron cores of the electro-magnets.

The current thus generated in the machine is sent into the wire or cable leading to the fuse by the opening of a shunt key. The fuse offers a great increase in its resistance at some point, by the interposition of a badly-conducting substance ; the consequent action is that the piece of bad conductor is highly heated, causing ignition of the explosive substance contained in the fuse.

The coils, whether of armature or electro-magnets, of the quantity exploder are wound with wire of large diameter to a total resistance of 8 to 10 units in about 2,000 windings ; electric currents possessing great heating power, but of low intensity, are therefore generated by this machine.

39. Dynamo-electric exploder for high tension fuses, also called spark fuses (intensity).

The construction is similar to the above, but this exploder has its coils, both of the armature and the electro-magnets, wound with fine wire to a total resistance of 2,000 to 2,500 Siemens' units, in about 17,000 windings. Upon causing the armature to revolve, currents are generated of great intensity, and passed by the automatic action of the machine into the wire or cable leading to the fuse, when an electrical spark passing between the separated conductors in the fuse inflames the explosive priming.

40. Case of electric cable samples.

41. Ditto ditto.

42. Ditto ditto.

1576ab. Wheatstone's Improved Automatic Telegraph System. Receiver and transmitter.

The British Telegraph Manufactory, Limited.

Sounder.

The British Telegraph Manufactory, Limited.

Wheatstone's Cryptograph.

The British Telegraph Manufactory, Limited.

Reversing Switch.
The British Telegraph Manufactory, Limited.

Double Plate Lightning Guard.
The British Telegraph Manufactory, Limited.

S. A. Varley's Lightning Guards (two on board).
The British Telegraph Manufactory, Limited.

1576c. Wheatstone's large Dial Indicator, for use with *A B C* instruments.
The British Telegraph Manufactory, Limited.

1576h. Double Current Key, for Wheatstone's Automatic Telegraph. *The British Telegraph Manufactory, Limited.*

1576i. Double Current Key, for Wheatstone's Automatic Telegraph. *The British Telegraph Manufactory, Limited.*

1576j. Rheostat for Duplex Telegraphing.
The British Telegraph Manufactory, Limited.

1576k. Testing Key.
The British Telegraph Manufactory, Limited.

1576l. Testing Key.
The British Telegraph Manufactory, Limited.

1576m. Testing Key for Discharges.
The British Telegraph Manufactory, Limited.

1576n. Lightning Guard.
The British Telegraph Manufactory, Limited.

1576o. Polarised Relay with Wheatstone's Patent Chain Adjustment.
The British Telegraph Manufactory, Limited.

1576p. Wheatstone Magnetic Counter with Magnet and Wheel showing Mode of Application.
The British Telegraph Manufactory, Limited.

1576q. Magneto-Electric Clock with Steam Engine Movement. *The British Telegraph Manufactory, Limited.*

1576r. Wheatstone's Roman Type Printer for use with the A B C Telegraph.
The British Telegraph Manufactory, Limited.

1576s. Wheatstone's Portable A B C Telegraph, specially arranged for Military Purposes.
The British Telegraph Manufactory, Limited.

1576t. Wheatstone's Alphabetical Magneto-Electric Telegraph. *The British Telegraph Manufactory, Limited.*

1576u. Polarised Morse with Wheatstone's System of Adjustment and Inking.
The British Telegraph Manufactory, Limited.

1576v. Translating Morse with Wheatstone's System of Inking. *The British Telegraph Manufactory, Limited.*

1576w. Resistance Box.
The British Telegraph Manufactory, Limited.

1576x. Resistance Box.
The British Telegraph Manufactory, Limited.

1576y. Large Standard Resistance Box.
The British Telegraph Manufactory, Limited.

1576z. Commutator.
The British Telegraph Manufactory, Limited.

1582. Meidinger's Galvanic Element.
Prof. Dr. Meidinger, Carlsruhe.

1583. Meidinger's Galvanic Element (larger size).
Prof. Dr. Meidinger, Carlsruhe.

For working telegraphs, electric clocks, and bell apparatus, also for electroplating in silver or gold.

1584. Box, containing a battery of 21 elements for producing constant currents for medical use. Entirely new construction of the exhibitor. *Prof. Meidinger, Carlsruhe.*

The glasses are filled with a solution of bichromate of potash and sulphuric acid in water. The gutta-percha covered rods are introduced into the wide glass, and the wires into the mercury tube, with which is connected a platinum wire, leading to the platinum sheets. After working the metal connexions are taken out of the glasses. The liquid is allowed to remain in the glass till it is exhausted; it may serve for 100 one-hour operations. In transport, the liquid does not escape, even in violent shaking. The stoppers with inserted glasses are never taken out. Filling is accomplished by pouring the liquid through the wide tube; emptying by inverting the glass, when the liquid flows out through the fine air passages. The gutta-percha under the zinc is gradually worn away in proportion as the (amalgamated) zinc is dissolved; only about a millimètre of free surface of zinc is necessary. The narrow trough is filled with very dilute zinc vitriol, and serves for regulating the strength of current by displacement of the zinc pole. On drawing out a peg, the liquid escapes below into a central vessel.

1585. Colour-writer (Morse), North German pattern.
L. E. Schwerd, Carlsruhe.

This is furnished with contact-arrangement for translation, and with commutator for sending the current through both electro-magnet coils either successively or simultaneously; in the latter case the resistance of the coils should be only $\frac{1}{4}$.

1586. Box Relay, N. German pattern.
L. E. Schwerd, Carlsruhe.

1587. Key, N. German pattern. *L. E. Schwerd, Carlsruhe.*

1588. Colour-writer (Morse), S. German pattern.
L. E. Schwerd, Carlsruhe.

This apparatus (much used in Baden and Bavaria) is adapted for either constant or working current.

1589. Pendulum Relay, S. German pattern.
L. E. Schwerd, Carlsruhe.

1590. Galvanometer, S. German pattern.
L. E. Schwerd, Carlsruhe.

The deflections of the needle correspond closely between 15° and 35° to the strength of current. The instrument is sensitive and easily portable.

1591. Key, S. German pattern. *L. E. Schwerd, Carlsruhe.*

1591a. Andrew's Guillotine Relay. *W. Andrews.*

The armature is a permanent horseshoe magnet, placed horizontally, and playing between two electro-magnets, the one above the other below the armature.

The upper electro-magnet is of the ordinary form, the lower one has the cross-piece removed and the poles of a horseshoe permanent magnet connected to its cores instead. The current passes through both coils, which are so connected that the electro-magnets act oppositely upon the permanent horseshoe armature, one attracting while the other repels.

The upper electro-magnet is movable in a vertical direction, and can be shifted up and down by an adjusting screw. This forms the chief adjustment, but a spiral spring is also provided for the purpose.

1591b. Morse Ink Writer, with **Relay** for translating connexions. *Warden, Muirhead, and Clark.*

1607. Uno-electric Pile with Galvanometer.
Landsberg & Wolpers (Hanover).

1635a. "Edison's Electric Pen," and **"Autographic Press."** *Thos. D. Clare.*

This pen consists of a small electro-magnetic engine on the top of a holder, which is used as a pen, and works a needle which pierces the paper, making 5,000 to 6,000 fine holes per minute, so that in writing such is the rapidity of the motion of the needle that the point does not drag or tear the paper.

The pierced paper or "stencil" is placed in a frame, and an inked roller is passed over, which fills the fine perforations with ink. A sheet of paper is then placed below the written paper or stencil, and the roller is again passed over once or twice, when a perfect fac-simile is obtained.

These fac-similes can be produced at the rate of four to six per minute, and one writing or stencil will suffice to print 1,000 copies.

1657. Original Five-Needle Telegraph Dial.
The Council of King's College, London.

1658. Two-Needle Telegraph.
The Council of King's College, London.

1659. Three A B C Telegraph Sending Instruments, showing gradual improvements.
The Council of King's College, London.

1660. Horizontal Sending and Receiving A B C Telegraph Instrument.
The Council of King's College, London.

1661. Two A B C Telegraph Receiving Instruments.
The Council of King's College, London.

1662. Punching Instrument, for preparing the paper for the transmitter. *The Council of King's College, London.*

1663. Transmitter.
The Council of King's College, London.

1664. First Electric Key, constructed by Sir Charles Wheatstone. *The Council of King's College, London.*

1665. Wheatstone's First Relay Instrument.
The Council of King's College, London.

1666. Printing Telegraph.
The Council of King's College, London.

1666a. Charge and Discharge Key.
Warden, Muirhead, and Clark.

1666b. Reversing Key. *Warden, Muirhead, and Clark.*

1666c. Short Circuit Key. *Warden, Muirhead, and Clark.*

1666d. Testing Key, for testing copper resistance. The battery circuit is completed first, then the galvanometer circuit by one movement of the finger. *Warden, Muirhead, and Clark.*

1666e. Perforated vitreous chamber, for interior of cell No. 1666d. *Warden, Muirhead, and Clark.*

1666f. Pair of Brequet Crossley A B C Telegraph Instruments. *Louis John Crossley.*

1558a. Model of a Morse Printing Telegraph (blue writer), with key, galvanometer, and paper stands.
A. Herbst, Berlin.

1667. Apparatus specially intended **to illustrate the Morse System of Telegraphy** in primary and secondary schools. *J. Cauderay, Lausanne.*

For the clockwork is substituted a small crank, which can be turned by hand. This apparatus works by means of a single Bunsen cell, of small size. Its low price, 40 frs., places it within the reach of every school.

1667a. Arm of Insulators, for land wires.
Warden, Muirhead, and Clark.

No. 1. Andrews white porcelain, ordinary, No. 8.
No. 2. Andrews white slot and hole at top.
No. 3. Andrews white slot.
No. 4. Do. brown, No. 8.
No. 5. Do. do. No. 11.
No. 6. Do. stoneware, No. 8.
No. 7. Brown porcelain, Post Office pattern.
No. 8. Clark's invert insulator.
No. 9. Spanish.
No. 10. New South Wales.
No. 11. Spanish larger hook.
No. 12. Varley's, No. 8.
No. 13. Indian Pattern.
No. 14. Warden's.
No. 15. Relays, No. 11.
No. 16. U shackle.
No. 17. Wardens perforated iron hook for iron poles.
No. 18. Z insulator.
No. 19. Bell hood (small).
No. 20. Do. (large).
No. 21. Bright's shackle.

1667b. Arm, with eleven **Insulators.**
Warden, Muirhead, and Clark.

1667c. Arm, with fourteen **Insulators.**
Warden, Muirhead, and Clark.

1669. Submarine Telegraphic Cables. *Geminiano Zanni.*

In the above specimens the conductor (consisting of one or more copper wires) is enclosed within a series of soft iron wires, which unite to form a strand or core by passing the combined series of wires through a bath of molten tin, or any other comparatively soft metal. The core thus combined into a solid body is protected from corrosion. It is then coated with gutta percha, or any insulating material, over which tin foil is wrapped to exclude moisture. A band of hemp (immersed in tar) is wound round the core to protect the metal foil from injury or corrosion.

1670. Ward's Dead Beat Telegraph.
William Sykes Ward.

Two delicate coils of fine wire are suspended on points around the poles of powerful permanent magnets; the motions are limited so as to give distinct indications without tremulous vibrations. Patented in 1847.

1671. Signalling Key for Telegraphy, to send into a line positive or negative currents. *Elliott Brothers.*

1671a. Small registering Electro-Magnet, capable of supplying 500 signals per second.
Marcel Deprez, 16, *Rue Cassine, Paris.*

1675. Apparatus for sending **simultaneously** in opposite directions **Telegraphic Despatches,** between two stations with one single wire in the line.
Elie Wartmann, Professor of Natural Philosophy at the University of Geneva.

A full description is to be found in the number for March 1856 of the "Bibliothèque universelle de Genève." The keys, when worked, close two different circuits, which are to be of such directions and intensities that they neutralise each other in the two sets of coils of the branches of the electro-magnets.

1678. Apparatus for **transmission** of two **simultaneous Telegrams** in the **same Telegraphic Wire,** from one station to another.

Elie Wartmann, Professor of Natural Philosophy at the University of Geneva.

A description of the method and apparatus is printed in the "Archives des Sciences physiques et naturelles," Geneva, November 1860.

1679. Apparatus for permitting any two **Stations** on the same **Telegraphic Wire** to communicate immediately without the aid of the intermediate ones, so that the despatch remains secret between them.

Elie Wartmann, Professor of Natural Philosophy at the University of Geneva.

For complete description see the "Bibliothèque universelle de Genève," May 1853. It consists of the following parts :—

a. Sender ; b. Regulator ; c. Indicator ; d. Interruptor. The principles of the instrument are: 1. To break the communication of every intermediate station with the earth; 2. To maintain the contact of their electro-magnets with the poles in order to facilitate the transmission of direct currents between the two stations to be united; 3 To let the officer in the station from which the despatch originates know that it is really received in the proper one; 4. To cut off immediately the communication after the receipt of an answer; 5. To reinforce the current of the battery in the first station by means of the batteries in all intermediate stations.

1238. The First Instrument used to **Electrify** the Ink-Bottle of the Siphon Recorder. *Sir W. Thomson.*

This was the first instrument used for producing the electricity required to electrify the ink-bottle of the siphon recorder. What is now known as the mouse-mill, referred to in Clerk Maxwell's "Electricity and Magnetism," is a modification of this instrument, driven by intermittent electro-magnetic force. Described in Thomson's reprint of "Papers on Electro-statics and Magnetism," xxiii. 416–419.

1239. Modified form of **1238.** *Sir W. Thomson.*

1240. Further developed form of **1238.**

Sir W. Thomson.

One of the applications of this is to multiply indefinitely the electro-static indications obtainable from a feebly electrified body on the same principle as Nicholson's Revolving Doubler, and as the rotating induction instrument exhibited by Mr. C. F. Varley at the International Exhibition of 1861.

1683a. Automatic Lightning Guard.

Warden, Muirhead, and Clark.

1683a. Eggington Automatic Lightning Guard, for protecting submarine cables from the effects of lightning and powerful earth currents. The land wire is automatically put to earth by the currents themselves and the cable left safely insulated.

Warden, Muirhead, and Clark.

1690a. Double Indexed Telegraphic Post, with alphabetical receiver, indicator, and printer; manipulator on Chambrier's system. *M. Deschiens, Paris.*

The whole of this apparatus is enclosed in a case for protection.

1691. Stock Exchange or **Bourse Telegraph Instrument.** *Siemens and Halske, Berlin.*

A battery is employed only at the central station, from which the messages are sent by depressing lettered finger keys on the transmitter, which are so arranged that the letters most commonly occurring are nearest at hand. Only one line wire is required. The receiving instrument prints in Roman type, and has a double type wheel carrying figures and letters, so that by depressing a changing key in the transmitting apparatus letters or figures may be printed at will. The type wheel automatically returns to its zero position after each printed signal, and is therefore always in adjustment.

1692. Magnetic Telegraph Apparatus.
Siemens and Halske, Berlin.

The transmitter may be any dial instruments in which the currents are generated by magnets. The receiving instrument prints upon a paper riband from a double type wheel, at the same time indicating on a dial the letters sent. The type wheel is of vulcanised caoutchouc instead of metal.

1693. Two Automatic Cylinder Transmitters and printing instruments working **Duplex,** *i.e.*, so arranged that messages may be transmitted from both stations simultaneously.
Siemens and Halske, Berlin.

The transmitter is an automatic finger key instrument, in which the letters to be transmitted are formed in Morse code upon a cylinder of wires, these wires being pushed forward by levers connected with the finger keys, so that by depressing the keys corresponding to the letter to be sent, the complete Morse signal is formed in the wires, which afterwards are brought by revolution of the cylinder into contact with levers connected to the battery and line.

1694. Automatic Type-printer, including transmitter, receiving instrument, and relays. *Siemens and Halske, Berlin.*

The transmitter is an automatic finger key instrument, in which the currents to be transmitted are controlled by a cylinder of wires, these wires being pushed forward by levers connected with the finger keys, so that by depressing the key corresponding to the letter to be sent the necessary combination is formed in the wires, which afterwards are brought by revolution of the cylinder into contact with levers connected to the battery and line, and by this means the numbers of currents requisite to bring the type wheel of the receiving instrument to the desired letter are sent into the line. The relay consists of a double armature of aluminium bobbins wound with silk covered wire, which are drawn into or expelled from an intense magnetic field, according to the direction of the current received in the coils from the transmitting instrument, the bobbins causing contact to be made by their movement. The receiving instrument has a double type wheel worked by an escapement, which is actuated by two electro-magnets brought into play by the currents received from the relay.

1694a. Printing Telegraph, invented by M. H. Jacobi, academician, in the year 1850. Two uniform apparatus for two stations.

Physical Science Cabinet of the Imperial Academy of Sciences, St. Petersburg.

1694e. Charge and Discharge Keys (new form).

Warden, Muirhead, and Clark.

1701. Magneto-electric Morse Ink Printing Telegraphic Apparatus. *Geminiano Zanni.*

The above instrument, consisting of the mechanical clockwork as in an ordinary electric Morse apparatus, has in addition a compound magnet arranged with an induction coil. The motion is given to the coil for the production of the magnetic current by the same clockwork as drives the paper forward; thus dispensing with the use of the voltaic battery.

1703. Pair of Undemagnetisable Coils, designed in 1866.

S. Alfred Varley.

The magnetic needles inside these coils are made of soft iron rendered magnetic by induction, instead of being made of tempered steel magnetised.

As the needles are magnetic only by virtue of the permanent magnets in their neighbourhood, the influence of powerful currents, induced by lightning, upon them, can only be momentary; consequently the telegraphic circuit is not liable to be interrupted by the demagnetisation of the needles, which so frequently occurs in needle telegraphs of the ordinary construction.

Extract from the Handbook of Telegraphy, by R. E. Culley, Engineer-in-chief of Telegraphs to the Post Office, 5th edition, pages 199, 200 :—

" The greatest improvement which has been made in the needle instrument is the introduction of an induced magnet of soft iron for the needle in place of the permanent steel magnet."

1704. Instrument for sending double-curb signals into submarine cables. *Sir William Thomson.*

This instrument was constructed in 1858, but not completed in time for trial on the transatlantic cable before its failure in the September of that year.

1705. Electro-magnet Relay for reaction produced by the magnetism emanating without regulation. Extremely rapid, and produces a novel double effect, something like the cut of a whip.

M. Guyot d'Arlincourt.

1706. Relay for Rapid Transmission.

M. Guyot d'Arlincourt.

Application of this relay for the transmission into the rapid apparatus. In this same apparatus two other relays called whipcuts discharge the line with each emission of the current.

1707. Autographic Apparatus. *M. Guyot d'Arlincourt.*

Employment of the circular vibration of the branches of a diapason for regulating the working of the apparatus. New correcting system for ascertaining at once the isochronous action of two apparatus that are not regulated perfectly one upon the other.

1708. Dial Printing Telegraph. *M. Guyot d'Arlincourt.*

Printing apparatus with electro-magnet of two planes and two effects; one of the planes at the open ends of the electro-magnet governs the receiver, the other at the heel produces the impression of the letter. When the positive and negative currents are thrown alternately and without interruption, the two planes act together, and the local circuit of impression is open. On the interruption of any current, the plane at the heel acts alone, the two planes are no longer united, and the printing takes place.

1709. Morse Sounder. *Dumoulin Froment.*

1709a. Morse's "Sender and Receiver." *Dumoulin Froment, Paris.*

1709d. Photograph of Telegraph Punching Apparatus. *C. H. G. Olsen, Christiania, Norway.*

1709e. Photograph of Telegraphic Printing Apparatus. *C. H. G. Olsen, Christiania, Norway.*

1709f. Photograph of Drawings of Telegraphic Apparatus. *C. H. G. Olsen, Christiania, Norway.*

1709g. MS. detailed Description of Automatic Printing Apparatus. *C. H. G. Olsen, Christiania, Norway.*

1709h. Drawing of Telegraphic Apparatus. *C. H. G. Olsen, Christiania, Norway.*

1709i. Two Copies of Pamphlet on Electric Telegraphy. *Senor F. Riano.*

1708a. Automatic Printing Telegraph, constructed by C. H. G. Olsen, Christiania. *C. H. G. Olsen, Optician, Christiania.*

This apparatus consists of two principal parts.

1. *The punching apparatus,* on which the messages are prepared thus:—By depressing one of the keys of a keyboard in the apparatus, holes will be punched in a paper ribbon, corresponding to letters and signs marked on the keys. Then this ribbon is rolled up and applied in—

2. *The printing apparatus,* where it is run over a metallic roller. Whenever a hole appears, a steel pin will make contact with the roller and send a current to the line. The current will liberate the armature of a magnet, by which a wheel with engraved signs and letters will revolve, and another paper ribbon, applied under this wheel, is lifted into contact with it. If the wheel has its right position to the writing on the perforated paper, the letter desired will appear printed on the paper. (2 photographs, 7 drawings, and a more detailed description follow.)

1709c. Contact Breaker, with two discs, which can be displaced, and sliding springs on glass inlets. *Prof. Dr. Dove, Berlin.*

(*See* Transactions of the Royal Academy of Sciences at Berlin, 1841, p. 296.)

1695a. Model of Aerial Telegraph, by Chappe.
Telegraphs Department, Paris.

1695b. Model of Aerial Telegraph, by Monge.
Telegraphs Department, Paris.

1695c. Model of Aerial Telegraph, by Bréguet and Bettancourt. (This model belongs to the Conservatoire des Arts et Métiers.) *Telegraphs Department, Paris.*

1695d. Model of the First French Electric Telegraph, with two needles. *Telegraphs Department, Paris.*

1695e. Electric Telegraph, by Hughes, with latest improvements. *Telegraphs Department, Paris.*

1695f. Autographic Apparatus, by Meyer, constructed by Mr. Hardy. *Telegraphs Department, Paris.*

1695g. Froment's Dial Telegraph.
Telegraphs Department, Paris.

SPECIAL APPLICATIONS.

1576d. Electric Fire Alarum, for warehouses, &c.
The British Telegraph Manufactory, Limited.

1696. Electric Alarum for indicating the heating of Axle Bearings. *C. & E. Fein, Stuttgart.*

This is intended to show the heating of an axle in its bearings, and for this purpose is placed in an opening in the cap piece, so that its lower end touches the axle. As soon as the temperature rises, contact is made and a bell rings. The metal of the bearings, plummer block, &c. serve instead of return wires, so that only one insulated conductor is required.

1697. Group of Apparatus, comprising an electric control clock, with six locking signal studs. *C. & E. Fein, Stuttgart.*

This is for use in manufactories, public buildings, &c. The dial is a paper disc, which is changed daily, and revolves once in 12 hours; it contains as many rings as there are stations. By pressing down a knob at any of the stations an electro-magnet inside the clock draws its anchor forward, and a mark is made on the dial. As the dial is very large, minutes can be read off easily. When a new dial is put on, the knob in the centre is to be turned so as to set the clock to the right time. The clock will go for several days, but it is better to wind it up daily. The signalling knobs can be kept locked up, and may be opened by the watchman with a key which is common to the whole apparatus.

1698. Battery Case, containing six large Meidinger's cells for working the above apparatus. *C. & E. Fein, Stuttgart.*

1699. Lamp with Double Screen, slide and adjustable lens, scale stand, scale, &c. To be used with reflecting galvanometers generally. *Elliott Brothers.*

1700. Magneto-electric Railway Passenger Signalling Apparatus. *Geminiano Zanni.*

This is for enabling the passenger in any part of a railway train to communicate with the guard or driver by simply touching a button, without the use of a voltaic battery.

1702. Magnetic Bells and Signals. *Geminiano Zanni.*

In the above the mechanical electric bell moved by clockwork, at present in use, is dispensed with. The motion of the coils is caused by moving a bell-pull lever half a revolution. Self-acting apparatus may, by this invention, be arranged for giving alarm in case of fire or burglary without the use of a voltaic battery; by adopting clockwork to set the coil in motion, the bell or signal would act on opening a door or window, or by the heat resulting from fire.

1673. Electric Domestic Bells (three). *J. Round.*

1674. Electric Detective Bell. *J. Round.*

1728a. Electrical Communicator. *Garnham & Co.*

This invention enables a perfect communication to be maintained between guards and drivers, and passengers and guards, by means of electricity. The want of a thorough system of communication between guards and drivers on trains has long been felt, as it is well known that the guard in the after part of a train cannot at all times hear the driver's whistle. By means of this electrical communication a perfect code of signals can be maintained. In the case of danger, passengers can readily give an alarm to the guard, and this passenger signal continues ringing until the guard replaces it, and it therefore indicates the compartment of a train in which the alarm bell was sounded. The apparatus consists of a simple battery with the necessary communicators; it is simple, inexpensive, and not liable to get out of order, and is also readily applied to all existing trains.

1576g. Magnetic Bell, with tell-tale.
The British Telegraph Manufactory, Limited.

1702a. Electrical Alarum with Leclanché's Battery.
Mariais, Paris.

This apparatus consists of a watch placed on a box which contains an electrical bell worked by two elements of a chloride of ammonium (called Leclanché's battery). The wire from the zinc is fixed in the binding screw No. 2, the wire from the carbon in the binding screw No. 1. When the small hand of the watch touches the piece which turns in the circular groove, the bell rings until the hand is released by turning the small handle which is at the side of the piece. The binding screw No. 3 which is above is to be used for the wire from the carbon when the apparatus is used as an ordinary electric bell. The polished stem which carries No. 4 binding screw can only be used for six hours, when the rod which carries the platinum point is clamped in the hole.

1702b. Lamp with Self-lighting Electrical Apparatus and Bichromate of Potash Battery. *Mariais, Paris.*

The battery inside is charged with bichromate of potash mixed with about one-tenth water. The lamp, the small tube of which can be seen, is an ordinary benzolin lamp with sponge; when once filled it is put in its place. By pressing on the central button the lamp is made by the mechanism of the apparatus to approach the platinum lighter (inflamateur), which is in the centre. On letting the button go, the lamp is lighted. The cover of the lamp should be replaced by the hand in order to prevent evaporation.

The box contains eight spare platinum plates.

1709b. Detector of Disorder in Pneumatic Telegraph Tubes. *M. Bontemps, Telegraph Inspector, Paris.*

a. With bell.
b. With differential manometer.

1703. Magnetic Ship Signal. *Geminiano Zanni.*

The above signal is composed of two parts, the sender and the receiver. For actuating the sender, merely turn the handle over to the order required to be sent, the dial of the receiver will indicate this order, and also repeat it back to the sender.

The magnetic current is caused by the motion of turning the handle or crank to the order; the use of the voltaic battery is dispensed with.

1709c. Elisha Gray's Telephone, an instrument for transmitting musical notes by means of electricity.

Warden, Muirhead, and Clark.

A. Board for transmitting the four notes of the common chord, and two receiving instruments, B, C.

A reed vibrating the note to be transmitted is caused to interrupt the current entering the line. At each vibration the interrupted current reproduces the note at the distant station by there setting a similar reed in vibration as in the electro-magnetic receiver B, or by the friction of the finger (through which the current is made to pass) on the zinc face of the revolving sounding board. By means of the telephone several messages may be sent along a wire at once, a different note being employed for each.

Application to Naval and Military Purposes.

1711a. Military Telegraph.

M. Trouvé, 6, Rue Thérèse, Paris.

This apparatus is characterised by the junction into one single object of the three parts which constitute a telegraphic post, viz., the monitor, the manipulator, and the reflector; and also by the smallness of its size, which enables a man to carry it on his back, with its cable, like a soldier's knapsack. To this apparatus are joined four time-pieces; the first two are tellers transmitting the despatch by sound. The two others have dials, movable and printed on both sides; the one has letters and figures, the other letters only, with blanks for tracing words, which allows of orders being sent as rapidly as by word of mouth.

Fuzes.

(*a.*) Wire or Low Tension Electricity Fuzes.

1712. Earliest form of Fuze used by the Royal Engineers for the explosion of mines by electricity (first used in removing the wreck of the "Royal George," Spithead, 1839).

F. A. Abel, F.R.S.

1713. Mining Fuze, platinum wire, improved construction by Chemical Department, Woolwich. Wire, ·003 inch in diameter (Abel's electric fuze, No. 1). *F. A. Abel, F.R.S.*

1714. Detonators, platinum wire, Chemical Department, Woolwich. Wire, ·003 inch diameter. *F. A. Abel, F.R.S.*

1715. Detonator (low tension), latest construction, with bridges of platinum-silver or indio-platinum wire (·0014 inch in diameter). *F. A. Abel, F.R.S.*

1716. Statham and Brunton's Fuze, 1854. Composition: sulphide of copper and fulminate of mercury. *F. A. Abel, F.R.S.*

1717. Von Ebner's Fuze, 1867 (earliest fuzes constructed by Von Ebner about 1855). Composition: coke, sulphide of antimony, and chlorate of potash; primed with gunpowder. *F. A. Abel, F.R.S.*

1718. Abel's High Tension Fuze, 1858. Composition: subphosphide of copper; primed with gunpowder. *F. A. Abel, F.R.S.*

1719. Abel's Fuze for Royal Engineer Service, 1862. Composition: subphosphide of copper; primed with gunpowder. *F. A. Abel, F.R.S.*

1720. Submarine Fuze, for instructional purposes only. Composition: blacklead and fulminate; priming, sulphide of antimony and chlorate of potash. *F. A. Abel, F.R.S.*

1721. Beardslee Fuze, 1864. Streak of blacklead between the poles; primed with gunpowder. *F. A. Abel, F.R.S.*

1722. Abel's Land Service Detonator. Composition: phosphide of copper; primed with fulminate of mercury. *F. A. Abel, F.R.S.*

1723. Submarine Detonator. Composition: graphite and fulminate of mercury; priming, fulminate. *F. A. Abel, F.R.S.*

1724. Gun Tubes (low tension). Original form, McKinlay. Gunpowder priming. *F. A. Abel, F.R.S.*

1725. Abel's Gun Tube (high tension). Original form. Gunpowder kept damp by chloride of calcium (1857). *F. A. Abel, F.R.S.*

1726. Gun Tube (high tension). Service, Abel's. Composition: subphosphide of copper, with tube of gunpowder. *F. A. Abel, F.R.S.*

1727. Gun Tube, naval, platinum, silver-wire, ·0014 inch in diameter. Composition: gunpowder and gun-cotton, with tube of gunpowder. *F. A. Abel, F.R.S.*

1728. Series of Specimens illustrating the development of the applications of Electricity to the explosions of mines, guns, &c.

1. Original form of wire fuze.
2. Statham fuze.
3. Platinum wire gun tube and section.
4. Experimental high tension fuze.
5. Abel's electric fuze and section. No. 1.
6. Abel's electric gun tube and section. No. 4.
7. Abel's platinum wire fuze and section. No. 5.
8. Austrian electric fuze (Von Ebner's) and section.
9. Abel's submarine fuze and section. No. 2.
10. Abel's electric detonator (land service) and section. No. 5.
11. Abel's electric detonator (submarine) and section. No. 7.
12. Naval electric gun tube and section.
13. Low tension detonator and section. No. 9.

Glass case and printed labels. *War Office.*

1576e. Magnetic Exploder and Fuzes.
The British Telegraph Manufactory, Limited.

c. ELECTRO-CHEMICAL APPLICATIONS.

1730. Application of the Electrotype Process to the Reproduction of Works of Art.
Messrs. Elkington and Co.

Reproduction of a medal. This is an object composed of two parts only, viz., the obverse and the reverse.

a and *b*. Moulds in gutta percha, &c. of the obverse and the reverse.
c and *d*. Moulds with the copper deposited in them.
e and *f*. Copper deposits removed from the moulds.
g. The two sides or portions of the medal as deposited, soldered together ready for finishing.
h. Electro-deposited copy or reproduction of the medal, gilt or silvered.

Reproduction of a small candlestick :

a. The moulds of the base and two sides of the nozzle in gutta percha, &c.
b. Moulds with the copper deposited in them.
c, *d*, and *f*. Copper deposits of the two sides of the nozzle of the candlestick, and the base removed from the moulds.
g. The same soldered together and fitted.
h. The candlestick silvered and completed.

1730a. Reproduction of the "Strauss" Tankard.
South Kensington Museum.

a. A copy or reproduction complete with fictile ivory body or drum.
b. Mould of the "drum."
c. Cast in fictile ivory.
d. Moulds with the copper deposited in them.

e. Copper deposits removed.
f. The same soldered together to form a metal "drum."
g. Moulds of the handle.
h. Moulds with the copper deposited in them.
i. Copper deposits removed from the moulds.
j. The same soldered together as part of the tankard.
k. A group of the other details of the tankard deposited in copper and removed from the moulds.
l. The tankard as soldered together and fitted with copper "drum," ready for gilding, &c.
m. Completed metal copy of the tankard, silvered and parcel gilt.

1730b. Group of Ferns, &c., in a basket, as an illustration of the method of coating natural objects, however delicate, with copper, and afterwards silvering or gilding the same.

The objects are first prepared with a metallic surface, then immersed in a solution of sulphate of copper, and afterwards electro-plated with gold or silver.

1730c. Electro Jewellery. *Gustave Trouvé, Paris.*

1731. Single Cell Apparatus, used in the Electrotype process. *J. How and Co.*

This consists of a glass outer cell furnished with a perforated shelf, with an upright porous vessel containing a zinc rod well amalgamated. The porous cell is charged with dilute sulphuric acid, and the object to be coated attached to the binding screw by a copper wire, and suspended in the outer glass vessel, which is filled with a saturated solution of sulphate of copper, a supply of crystals of this sulphate being placed upon the perforated shelf for the purpose of keeping up the strength of the solution.

Smee's Battery, used in the Electrotype process.
J. How and Co.

This consists of a central platinised silver plate for the negative element between two zinc plates, connected together by a clamp. It is charged with dilute sulphuric acid.

1731a. Daniell's Constant Battery, used in the Electrotype process. *J. How and Co.*

The outer copper cell forming the negative element; the positive element consists of a rod of zinc placed in a porous cylinder. To charge the battery the porous cell is filled with dilute sulphuric acid and the outer cell with a saturated solution of sulphate of copper, crystals of the sulphate being placed upon the perforated shelf of the outer cell for the purpose of keeping up the strength of the solution.

1731b. Bunsen's Battery, used in the Electrotype process. *J. How and Co.*

This consists of a negative element of carbon contained in a vessel of porous earthenware, which is surrounded by a cylindrical zinc positive element in an outer glazed earthenware cell. It is charged by placing concentrated nitric acid in contact with the carbon, and dilute sulphuric acid in contact with the zinc. The zinc is required to be kept well amalgamated.

1731c. Glass Decomposing Cell, used in the Electrotype process. *J. How and Co.*

Consists of a glass vessel fitted with two insulated brass bars, with attached binding screws. A piece of sheet copper is hung upon one of the bars, and the object to be coated on the other. The vessel is nearly filled with a strong solution of sulphate of copper. The zinc pole of a battery (say Daniell's) is connected with the bar to which the mould or object to be coated is attached, and the copper pole to that upon which the sheet copper is suspended. This apparatus will also answer for depositing silver and gold.

1732. First Electrotype Reproduction obtained by M. Jacobi. *Conservatoire des Arts et Métiers.*

1732a. Ten Copper Plates, engraved by the electro-chemical process, the proofs from which are in the accompanying album. *Erhard, Paris.*

A proof, fresh printed from a lithographic stone, or an autograph, or a proof from a copper plate wanting to be renewed, is by this process transferred to a copper plate, and produces in a few moments an engraving en creux as clear as that from the original plate, which is in no wise damaged by the operation. By this process it is possible: 1. To avoid having to preserve stones, at once brittle and cumbersome. 2. To reproduce a worn out plate, and so secure unlimited copies. 3. To effect, upon the copper plate, corrections not feasible upon the original plate worn out by previous printings.

1732c. Electric Multiplier. *Prof. George Fuller, Belfast.*

XII.—SPECIAL COLLECTIONS OF APPARATUS.

4566. Photographs of collection of **Apparatus formerly belonging to Volta.**
Liceo Volta of Como, Cabinet of Physics and Chemistry, Prof. Giovanni Gambara.

1. Small voltaic pile.
2. Small voltaic pile with circle of cups.
3. Electrophorus.
4. Two wooden discs covered with silk.
5. Electroscope.
6. Apparatus for igniting hydrogen gas by the electric spark.
7. Glass electrical pistol of Volta.
8. Eudiometer of the same.
9. Small squares of zinc and copper for generating electricity.
10. Glass tube containing mercury, for determining the coefficients of the expansión of air.
11. Small case made expressly for the protection of the above instruments.

1733. Original Apparatus with which **Faraday** obtained the Magneto-Electric Spark.
The Royal Institution of Great Britain.

A welded ring of soft iron six inches in diameter, $\frac{7}{8}$ of an inch thick, one part covered by a helix A containing about 70 feet of insulated copper wire occupying about nine inches in length upon the ring. The other part covered by a second helix B containing about 60 feet of insulated copper wire. The helices are separated from each other at their extremities by half an inch of the uncovered iron.

The iron ring was converted into a magnet by passing a voltaic current through the helix A. This induced an electric current in the helix B, and a small spark was for a moment seen at the carbon terminals.—Phil. Trans. 1831.

1733a. Siberian Loadstone and Spark Apparatus. This was the loadstone employed by Faraday in his experiments on magneto-electric induction, from which he first obtained the induction spark. (*See* Exp. Researches, vol. II.).

The Council of King's College, London.

1734. Faraday's original Apparatus for Magneto-Electric Induction by a permanent magnet.

The Royal Institution of Great Britain.

A paste-board tube is surrounded by a helix C of insulated copper wire. The diameter of the tube allows a cylindrical bar magnet to pass freely into it. The terminal wires of the helix are connected with a galvanometer. On the introduction of a permanent bar magnet into the helix, and on its withdrawal from it, currents of electricity were induced in the helix which caused a deflection of the galvanometer needle.—Phil. Trans. 1831.

1735. Faraday's Rotating Rectangle for illustrating the inductive action of the earth.

The Royal Institution of Great Britain.

The wire rectangle provided with a commutator for collecting the currents was attached to a galvanometer, and rotated across the line of the magnetic meridian, the electric current induced in the rectangle deflecting the galvanometer needle.—Phil. Trans. 1852.

1736. Various Helices, Spirals, &c. used by **Faraday** in his researches on Magneto-Electric Induction, &c.

The Royal Institution of Great Britain.

Phil. Trans., 1831.

1737. Magnet made by **Static Electricity,** with note by Faraday. *The Royal Institution of Great Britain.*

" A magnet made at the London Institution by an electric discharge from 70 square feet of charged surface. Present, Sir H. Davy, Pepys Jordan, Bostock, and Faraday."—Note by Faraday.

2434. Metallo-Chrome. A specimen prepared by Nobili, and presented by him to the Royal Institution. *Mrs. Faraday.*

1739. Diagrams of magnetic Curves, prepared by Faraday.

Mrs. Faraday.

1740. Coils and Helices, used by Faraday in his magneto-electric researches. *Mrs. Faraday.*

1741. Model frequently **used by Faraday** during his researches on the rotation of a ray of polarised light by electricity and magnetism. *Mrs. Faraday.*

1742. Block of Glass pierced by sparks from an induction coil. Presented to Faraday by M. Ruhmkorff, 1861. *Mrs. Faraday.*

1232a. Daguerreotype Portrait of Faraday. *Mrs. Charles Cowper.*

1232b. Daguerreotype Portrait of Faraday and Brand. *Mrs. Charles Cowper.*

1742b. Original Apparatus, by Arago and Matteuci. *Polytechnic School, Paris.*

1742a. Apparatus constructed by **A. De la Rive** for demonstrating the rotatory motion which an electric discharge in rarefied gas performs around a magnet.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

This apparatus consists of an electric shell, perforated by a soft iron cylinder, magnetised by placing it on one of the poles of an electro-magnet. The electric discharge is produced between the extremity of the soft iron cylinder, which is insulated by a glass tube, and a metallic ring which encircles the soft iron. As soon as the soft iron is magnetised, the electric discharge begins to revolve around it. Previous to Ruhmkorff's improvements in induction-coils De la Rive made this experiment with the current of the "Armstrong" machine.

1742aa. Diagrams and MS. by Henry Cavendish (40 sheets), the property of his Grace the Duke of Devonshire. *The Cavendish Laboratory, Cambridge.*

These form part of the hitherto unpublished papers of Henry Cavendish. The experiments described were made in the years 1771–2–3, and relate to electrical measurements.

He first establishes the law of the inverse square by proving that if a globe is insulated inside a hollow sphere, and then put in connexion with the hollow sphere, and the whole highly electrified, and if the globe is then insulated and the hollow sphere removed, the globe is found to be without charge.

He then describes a method of measuring the electric capacities of bodies, and applies it to a globe, to discs of different sizes, to squares of different sizes and substances, and to long cylinders and wires, comparing his results in each case with his calculations.

1742c. Apparatus devised by **De la Rive & Sarasin** for demonstrating that the electric discharge in a rarefied gas, turning under the power of a magnet, draws with it in its rotatory motion the gas which tranmits it, and all bodies, sufficiently light, that it meets with in its course.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

A bell-glass stands upon a platten, which itself must be placed upon the pole of an electro-magnet. This glass being filled with rarefied gas, the electric discharge is completely effected between the central brass ball, and a ring of the same metal constituting the other electrode. A sail-wheel is adjusted inside this ring, so that its vertical paddles may be upon the direct line from the ball to the ring, whereby the discharge strikes it in revolving under the action of the magnet. It then gives it a rotatory direction as soon as the direction of the magnet is changed.

(*See* Archives des Sciences, vol. 45, p. 387; Philosophical Magazine, vol. 44, p. 149.)

1743. Induction Coil by Bonijol, an old Genevese maker.
De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

Bonijol constructed a great number of electrical apparatus under the direction and with the advice of G. and A. De la Rive.

This coil, in which by means of a single medium sized element of constant power, induced currents of considerable force may be produced, was frequently used by A. de la Rive in his researches.

See "Archives de l'Electricité" by De la Rive, 1841, Vol. 1, p. 280.

1744. "Bréguet" Thermometer, used and referred to by **A. De la Rive** in his works upon the causes of voltaic electricity, and upon the properties of magneto-electric currents.
De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

1746. Galvanic Battery, by **A. De la Rive.** Modification of the **Grove Battery,** with nitric acid on the exterior. Constructed by the Geneva Association for the Construction of Scientific Instruments.
De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

The nitric acid is placed in a large glass phial, and in sufficient quantity to serve for a long time without being changed.

The diaphragm containing the acidulated water and the zinc closes perfectly the orifice of the phial; when the battery is taken to pieces, this diaphragm is replaced by a glass stopper. By this arrangement, the disengagement of nitrous vapour is avoided. This battery may thus safely remain in the experimenting room, close to the apparatus, and is especially suited for working a Ruhmkorff coil. Two elements suffice for a medium sized coil. De la Rive constantly used this apparatus for his researches upon induced currents, and always left it in his laboratory.

1747. Floats, constructed by **Gaspard de la Rive.**
De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

Apparatus intended for the demonstration, in a simple manner, of the "Laws of Ampère" upon the reciprocal action of currents. The conductors can be adapted directly to a small floating battery.

1748. Apparatus, by **A. De la Rive,** for the derivation and the relative measurement of **Induced Currents,** and used by him in his studies upon rarefied gases.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

This was used for diverting into a galvanometer a very small portion of an induction current, which passes through a glass trough filled with distilled water, in which are dipped two platinum wires, joined to the galvanometer. The current passing through the thin liquid thread placed between the wires is partially diverted into the galvanometer, which thus measures a quantity proportioned to the total intensity of the induced current that may go through the trough.

The deviation of the needle of the galvanometer increases proportionally with the distance between the wires.

This apparatus was often used by De la Rive in his researches on the passage of the induced current through rarefied gases.

1748a. Apparatus used by **De la Rive and Sarasin** to demonstrate that **Rarefied Gases,** crossed by inductive discharge, become condensed under the action of magnetism.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

The induced current passes through the tube with two compartments, one of which is placed between the two poles of a powerful electro-magnet; the glass cock is rapidly turned round, thus interrupting the current, and separating the two compartments. These are afterwards brought into communication with a very sensitive manometer, and it is then found that the pressure is a little greater in the one which has been between the two poles of the magnet, and which will also contain the negative electrode.

(*See* Archives des Sciences Physiques et Naturelles; new period, vol. 41, p. 5; and Philosophical Magazine, 4th series, vol. 42, p. 211.)

1748b. Apparatus used by **A. De la Rive** in his Studies upon the **Magnetic Rotatory Polarisation** of **Liquids.** (Made by the Geneva Association for the Construction of Scientific Instruments.)

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

1. Nicol polariser.
2. Tube for holding liquids, with double wrapper for the heating, required for studying the influence of the temperature upon the phenomenon.
3. Analyser, with graduated circle and special register, invented by M. Thury. This consists of two tangent discs in ivory, the one supported by the analysing Nicol, the other by the pinion that helps to turn it, and of a horizontal ruler. A pencil mark made by this ruler on both discs shows the position of the Analyser. Instead of having to read each observation separately, which is inconvenient in experiments made in the dark, the corresponding mark to every observation is simply noted, and afterwards read altogether. (*See* Archives des Sciences Physiques et Naturelles, vol. 38, p. 209.)

1749. Apparatus designed by **Auguste De la Rive,** for the demonstration of the **Electric Theory** of the **Aurora Borealis.**

Made by the Geneva Association for the Construction of Scientific Instruments.

De la Rive Collection. The property of Messrs. Soret, Perrot, & Sarasin, Geneva.

A large sphere, made of wood, represents the earth. Two iron cylinders represent the two extremities of the terrestrial magnetic axis. They penetrate into two globes filled with rarefied air, which simulate the higher regions of the polar atmosphere. The electric discharge, which takes place in this rarefied air, following rays all around a point situated in the prolongation of the terrestrial axis, turns about this point, and so turns in a different direction at either pole, when the two cylinders are charged by means of a horse-shoe electro-magnet, in accordance with the observations upon the rotation of the rays of the Aurora Borealis. See "Archives des Sciences physiques et naturelles," 1862, vol. 14, p. 121. Philosophical Magazine, 4th series, vol. 23, p. 346.

1750. Metallic Plates, for Watch Case, used by A. De la Rive in his first experiments in galvanic gilding.

Lucien De la Rive, Geneva.

1745. Photographs of a Special Collection of Instruments used by Volta.

Royal Lombardian Institution of Science and Letters.

1st Plate :

1. Electrophorus, with mastic cake, designed by Volta.
2. Condensing electrometer, the same which Volta made use of to demonstrate metallic electricity.
3. Columnar pocket pile, adopted by Volta to demonstrate his theory at the Institute of Paris in the presence of Buonaparte.
4. Original letter of Volta.
5. Lamp for hydrogen gas, which is ignited by the electrophorus. It has the form of the lamps which Volta introduced so largely into Germany.
6. Apparatus employed in the first researches of Volta, for collecting and rendering appreciable the smallest quantities of electricity.

2nd Plate :

The same instruments on smaller scales.

3rd Plate :

Fac-simile of part of a letter of Alexander Volta to Professor Bartletti, dated Como, 15th April 1777.

1473. Apparatus for covering wire with silk for electric purposes. *H. Lloyd, Trinity College, Dublin.*

1751. Polar-light Apparatus.

Prof. Lemström, Helsingfors, Finland.

Report of a speech of Dr. Lemström on his Polar-light apparatus, and the theory of the Polar-light.

This apparatus serves to prove that the polar light or aurora borealis is an electric current flowing from the higher regions of the atmosphere down to the earth.

A sphere of brass is fixed on a bar of india-rubber or ebonite 0·6 meter long, which is screwed to the board of the cross-shaped stand. A cylinder of india-rubber, 3 meters long, is fixed to the same board at about 0·7 meter from the sphere. From the cylinder proceeds a branch with an arm, both of india-rubber. On the arm are fixed 16 Geissler's tubes, the air in which has a pressure of about 0·5 millimeter. The lower ends of the tubes are pierced by platinum wires, which are directed towards the sphere, whilst at the upper end the platinum wires are, by means of their copper wires, in a metallic union with a button, and also in metallic union with the earth. From underneath the sphere a copper wire, well insulated with india-rubber, leads to the negative pole of a Holtz's electric machine (a machine by Carré of Paris was employed with great advantage), of which the positive pole is in metallic connexion with the earth. As soon as the machine is put in movement, the sphere, being charged, becomes negatively electric, and at the same time there goes through all the tubes a current of reddish-lilac light, so that they altogether form a shining bow-shaped belt. With an ordinary machine this phenomenon may still be observed when the lower ends of the tubes are at a distance of *two meters* from the sphere. This proves evidently that the electricity flowing out from (or into) the sphere not only traverses the layer of air that is between, but goes also with such power through the tubes that the gas therein becomes incandescent from the heat that the electric current produces, as is well known. In order that the electricity might more easily flow out in the air from the sphere, this latter is furnished with points. These points, as well as the metallic union between the upper end of the tubes and the earth, are of no absolute necessity, for the phenomenon may be produced without them, but in that case the distance between the sphere and the tubes must be considerably reduced.

The light produced by the apparatus proves clearly that a current of electricity may go through a layer of air of ordinary pressure 760^{mm} without producing the phenomenon, but if it meets in its way a space of rarefied air of low pressure (from 0 to 30^{mm} to 40^{mm}) the light immediately arises, the current causing the molecules of gas to become incandescent.

On the Theory of Polar-Light.

The knowledge we have acquired of the electric state of the earth proves that it is a conducting body, charged with a small quantity of negative electricity, and surrounded by the atmosphere, in general charged with positive electricity. Though this latter might be produced by an influence from the earth, it is still very probable that it proceeds from the process of evaporation, either directly or by the friction of vapour against particles of air. The atmospheric air possesses a very small conducting power for electricity when dry and at ordinary pressure, but the conducting power increases considerably as soon as the air becomes moist and rarefied. It has been proved by experiments that the conducting power is highest at a pressure between 5^{mm} and 10^{mm}, and amounts to 10,000 times that at a pressure of 760^{mm}. If the rarefaction of the air is carried further than 5^{mm}, the conducting power diminishes again, but very slowly. It is known that in proportion to the elevation above the surface of the earth the air becomes more and more rarefied according to the law expressed by the formula given by Laplace, and that consequently, at a certain elevation the earth is surrounded by a layer of air that has a pressure of only 5^{mm}; the conducting power for electricity in this layer is sufficiently great to allow of its being regarded as a conductor in comparison to the air in the lower regions, and even in the highest. The negatively electric earth is thus surrounded by a conductor of electricity concentric with it. All the positive electricity that attains the region of rarefied air at about 5^{mm}, or, as it might be called, this air conductor, submits almost to the same laws as if it were in a real conductor, and must thus be distributed in a manner depending on the influence of the electro-negative earth. Part of the electricity, conducted by the vapours, remains on the clouds in the atmosphere and discharges in form of lightning; another part attains the region of rarefied air, owing to the fact that the vapour itself, submitting to well-known physical laws, rises to this elevation, and also because electricity tends to distribute itself on a conductor.

The manner in which the electricity distributes itself between the two conductors depends on their relative position as well as on their form. The earth may, with sufficient approximation, be considered as spherical, as well as the air conductor, but in their position relatively to each other it appears that the region of rarefied air at 5^{mm} approaches much nearer to the earth at the poles than at the equator, principally in consequence of the difference of the temperature of the air in the two places. If we assume the mean temperature of the air round the equator to be 25°, at the poles $-12°$, and everywhere on the air conductor $-60°$, and we suppose at the same time the air everywhere half saturated with moisture, and that the temperature is reduced in proportion to the elevation, we find, if the above-mentioned formula of Laplace (1*) is applied, that the air conductor must at the equator be at an elevation of 37·47 kilometers, and at the poles 34·25 kilometers.

In consequence of this relative position, if the two conductors are regarded as conducting surfaces, the electric density on them both becomes about 9 per cent. greater at the poles than at the equator, and the power, by which the two electricities endeavour to unite, at least 20 per cent., but probably, if all the circumstances are considered, 30 or 40 per cent. greater at the poles than at the equator. In these facts then must be sought the principal cause of the accumulation of electricity at the poles of the earth and of the phenomenon occurring there, called polar-light or aurora borealis.

It is a remarkable fact that thunderstorms diminish in number as well as in intensity in moving from the equator towards the poles, and that at the 70th degree of latitude they cease completely, exhibiting once more in the highest north vestiges of their primitive intensity. In Finnish Lapland, for instance, thunderstorms are very uncommon, but when they occur they are extremely intense, and are almost always accompanied by thunderbolts. This peculiarity has probably its cause in the fact that the region of thunderclouds descends towards the earth in accordance with the same rule as the before-mentioned air conductor. The reduced number of thunderstorms is caused by the fact that the very source of electricity in the atmosphere, that is to say, the evaporation, is very much reduced; however, another important cause is here active, namely, the heightened conductive power that the air possesses in consequence of its greater saturation with moisture, whereby the electricity becomes unable beyond a certain latitude to remain upon the clouds, until it has attained a greater tension, but is conducted down to the earth in form of a slow current, visible in the polar-light.

It results from experience, with a high degree of probability, that the polar-light is an electric phenomenon, for its effects are of the same nature as those of the electric currents. Thus the polar-light causes disturbances in terrestrial magnetism, induces currents in telegraphic wires, and furnishes a spectrum of nine bands, which, with one exception, coincide with those produced by an electric current passing through rarefied air. Thus there is no doubt that the polar-light is caused by an electric current passing from

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(1*) $X = 18{\cdot}393$ metres $(1 + 0{\cdot}002837 \text{ Cos. } 2\,\phi)\ \frac{(1+0{\cdot}004T+t)}{2}\ l\ \frac{H}{h}$ where X signifies the elevation, ϕ the latitude, T the temperature at the surface of the earth, t at the upper point H, and h the reduced height of the barometer for the same points.

the upper rarefied layers of air to the earth; this current, during its passage through the rarefied air, produces light phenomena that cannot arise in denser layers of air.

The polar-light apparatus now exhibited shows that an electric current passing from an insulated body does not produce any light in air of normal pressure, but as soon as it rises to the rarefied air in the Geissler's tubes, there is directly produced a phenomenon very like the real polar-light. In the apparatus the upper end of the tubes is in union with the earth; this is by no means necessary, for the light phenomenon is also produced if this union be removed, provided that in such case the tubes be brought a little nearer to the insulated sphere. For the rest, the earth represents here the wide space of rarefied air that we find beyond the limits of the air conductor, and which serves here as an electric reservoir.

To consider now how the polar-light on a large scale is formed in nature. As before said, the earth and the air conductor hold to each other the position above mentioned, and the two electricities, the negative electricity of the earth and the positive electricity of the air conductor, endeavour with a certain force to unite in a belt around the north pole. The insulating power of the denser air prevents this reunion; but if we assume that the equilibrium is attained, the union will instantly take place as soon as this insulating power is diminished or the electricity on the conductor augmented. The first case, which probably is the most ordinary, happens if a southerly wind carrying a quantity of vapour attains the polar regions; for instance, the belt, where the vapour, in consequence of the cold, is condensed into a fluid form, reduces considerably the insulating power of the air and enables the electric current to flow through it. The same thing would occur if a layer of clouds happened to enter into this belt; the upper end of the cloud would become negatively electric, the lower one positive, and thus the distance between the two conductors would in fact be diminished. The electric current would go from the air conductor to the cloud, and through this latter to the earth. Similar phenomena are observed in the polar regions, for the upper edges of the clouds are not unfrequently seen shining with a yellowish light stretching considerably upwards, whilst no light is discernible under the cloud because of the air there having attained a density sufficient to prevent the current from producing light.

For further details of the polar-light and its theory, see Archives des Sciences Phys. et Natur. de Genève, 1875 (Sept. and Oct.), and in January 1876, as well as to two essays published in the years 1869 and 1873 in the same scientific journal, all which articles are more or less the result of observations made in the arctic regions. Besides these may be mentioned the works upon polar-light of the American natural philosopher Loomis, Rep. of Smithsonian Ins., 1865, &c.

4558. Photograph of a Dielectrical Machine, system of Prof. Cecchi. *Prof. Filippo Cecchi, Florence.*

4559. Photograph of an Electric Motor, on the plan of Prof. Cecchi, of Florence. Two rectilineal electro-magnets with polar masses of iron are alternately magnetised, and by means of levers and eccentrics produce the motion.

Prof. Filippo Cecchi, Florence.

The electro-magnetic motor of Prof. Cecchi, of Florence, is set in movement by two rectilineal and parallel electro-magnets placed horizontally upon a wooden base. Each of these electro-magnets bears at one end a mass of soft iron, while from the other projects a metal point, which by means of a small band moves a long lever of the third order, and this last moves by means of another very long band an eccentric, situated on the axis of revolution. On this same axis there is also a commutator which serves to send a current of electricity alternately into one and the other of the electro-magnets. This motor, on equal conditions, has a force superior to that of many other electro-magnetic motors.

SECTION 11.—ASTRONOMY.

West Gallery, Ground Floor, Room L., and the Terrace overlooking the Horticultural Gardens.

I.—INSTRUMENTS FOR DETERMINING THE PLACES AND MOTIONS OF THE HEAVENLY BODIES.

a. Astrolabes.

1752. Suspension Astrolabium. A very old astronomical instrument made in 1525. *Prof. Buys-Ballot, Utrecht.*

1752a. Astrolabe, date 1374. This instrument affords one of the oldest illustrations of the use of Arabic numbers. *A. C. Baldwin.*

1752a. Ancient Astrolabe, by Petrus Raimondi, 1375. *A. C. Baldwin.*

This instrument is 4 inches in diameter, with five interchangeable discs, astronomical circles, and two pointers. On the back, a zodiacal calendar. Round the edge is the inscription, "+ hoc astralabium : fuit factum : et cum armillis verifficatum Barghinone : anno Xri 1375. per Petrum Raimōdi de domo regis Aragonum : lati Barghinone : 41 longi 39."

1753. Astrolabe, constructed for Sir Francis Drake, prior to his first expedition to the West Indies in 1570. *Royal Naval Museum, Greenwich.*

This instrument is said to have been preserved in the Stanhope family till 1783. It was subsequently presented to King William IV., who in 1833 deposited it in Greenwich Hospital.

1754. Astrolabe. Ivory, mounted with gilt ormolu. A figure of the Creator is engraved outside. It still retains the original compass and needle. Nuremburg. Dated 1585. *Rev. J. C. Jackson.*

1754a. Ancient Astrolabe, supposed to have belonged to the Spanish Armada. *Robert J. Lecky, F.R.A.S.*

This instrument was found under a rock in the island of Valencia, Ireland, 1845, within view of the place where three vessels of the Spanish armada were wrecked, and from the style of its finish and workmanship is supposed to have belonged to one of them.

1755. Persian Astrolabe.

The Royal United Service Institution.

Presented to the United Service Institution, May 1842, by Major-General Sir John May, K.C.B., K.C.H.

1756. Ptolemy's Planisphere or Astrolabe, made in 1601, by Michael Coignet, at Antwerp. (See the works of Gemma Frisius, Metius, Lansberghen, &c.)

H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

1757. Ptolemy's Planisphere or Astrolabe, made in the beginning of the 16th century. (See the works of Gemma Frisius, Metius, Lansberghen, &c.)

H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

1757a. Large Bronze Astrolabe, which belonged to King Philip II., of Spain. *Archæological Museum, Madrid.*

Near the handle are the following inscriptions, giving the date and name of the maker:—

Philippo Rege. Gualterus Arsenius Frisi Nepos Lonanii fecit an 1555. The diameter of this instrument is $0 \cdot 59^{m}$.

1757b. Bronze Astrolabe, made in the 16th century. Diameter, $0 \cdot 32^{m}$. *Archæological Museum, Madrid.*

1757c. Arabian Astrolabe. Made at Toledo, A.D. 1067. Diameter, $0 \cdot 24^{m}$. *Archæological Museum, Madrid.*

Astrolabe made at Toledo as stated in the Arabic inscription engraved at the back : "In the month of Shawan. One of the works superintended by "Ibrahim Ibn Said, the Muazini, Assohli, at Toledo. In the 459th year of "the Hegira."

This year began on the 21st of November of 1066, and ended on the 10th of the same month of 1067. The famous astronomer Ararquiel, called by Guillermo Anglicus, *Pater Isaac*, lived at Toledo at this period, and this instrument may have been made under his directions. It contains five plates giving the latitudes. The translations of the inscriptions will be found in the interesting study on astrolabes, published by Dr. Eduardo Saavedra in the "Museo Español de Antiguedades," V. VI., pp. 402-414. It is worthy of notice that European numbers are to be met with on several of the plates, which would make it appear probable that the instrument had been used by some Christian astronomer not knowing Arabic. The number of towns mentioned, ranging from Persia to the coast of Movono, and several Spanish towns, is much more extensive than on similar instruments of the kind.

1757d. Bronze Arabian Astrolabe. Diameter, $0 \cdot 21^{m}$.

Archæological Museum, Madrid.

Astrolabe without name of maker, date, or locality ; but it may be surmised from the Arabic inscriptions on it that this instrument was made at Morocco, in 1774.

1757e. Memoir written by Don Eduardo Saavedra upon several Arabic astrolabes existing in Spain, published in the "Museo Español de Antiguedades."
Archæological Museum, Madrid.

1757f. Bronze Astrolabe, without date or maker's name, and was probably made in Italy in the 16th century.
Ministry of Marine, Madrid.

1758. Two Astrolabes, with four double sights; belonging to H.H. the Prince of Pless. *The Breslau Committee.*

1759. Astrolabe, with movable sun-dial; belonging to H.H. the Prince of Pless. *The Breslau Committee.*

32. Astrolabe of Lord Dudley.
The Royal Institute of "Studii Superiori," Florence.

Robert Dudley, Duke of Northumberland, spent many years of his life at the Florentine Court. He died on the 6th of September 1649, at Florence. Although not an Italian instrument, his astrolabe is exhibited as a mark of courtesy to England.

Astrolabe of a Florentine author, with seven change discs, one of them with a geographic planisphere.
The Royal Institute of "Studii Superiori," Florence.

Astrolabe of an Italian author, with a planisphere of Rojas.
The Royal Institute of "Studii Superiori," Florence.

Astronomical Ring of Ignazio Danti, a celebrated astronomer and mathematician of Perugia.
The Royal Institute of "Studii Superiori," Florence.

Fra Ignazio Danti, a Dominican, erected, under Cosimo I. (1537-1564), an armillary circle and a sun-dial, which are yet to be seen, on the façade of the Church of Santa Maria Novella in Florence.

1760. Arabian Planisphere. *Royal Museum, Cassel.*

A small apparatus, of Arabian origin, remarkable for its great age and comparatively good workmanship. It is in the form of a plate made of brass, 16 c.m. in diameter, provided with means for hanging up, and has a movable alhidada. The front side shows a planisphere, the back various divisions and tables covered everywhere with Arabian characters. On nine transposable and one fixed plate can be shown 19 different planisphere drawings for the same number of polar altitudes.

1761. Combined Planisphere and Astrolabe.
Royal Museum, Cassel.

A very strong plate of brass, 37·5 cm. in diameter, with an arrangement for free suspension. On the one side is a planisphere with web, on the other an astrolabe with double sight. The instrument dates from the 15th or 16th century.

1762. Astronomical Circle, after Gemma Frisius, made in 1572, by Gualtherus Arssenius, grandson of Gemma Frisius.
H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

b. ALTAZIMUTH INSTRUMENTS.

1763. 12-inch Altazimuth. *Troughton & Simms.*

Circles, 12 inches in diameter, divided into spaces of 5′ arc; by means of the attached microscopes these spaces are further subdivided, one division upon the micrometer = 1″ arc.

1763a. Pocket Altazimuth on Small Stand for altitudes, compass bearings, &c., improved by Francis Galton, F.R.S., and specially adapted for travellers. *L. Casella.*

1763b. Altazimuth Instrument, made by Dollond with double altitude circles. *W. Watson and Son.*

The instrument stands on three adjusting foot screws, above which is the azimuth circle with a telescope attached. The azimuth circle is an arrangement of one circle turning within another, so made that their upper surfaces are in the same plane, and the inner edge of the larger in contact with the outer edge of the smaller. The outer edge of the smaller circle carries the divisions, and the inner edge of the larger circle three verniers; the graduation is to 10 minutes of arc; above these is the large conical axis of the azimuth circle, from the top of which spring rectangular arms carrying the altitude circles, and telescope. The telescope is mounted between two 12-inch circles, the peripheries of which are divided on silver to 10 minutes of arc, each circle has two verniers and is furnished with tangent screw movements. Lamp with graduating aperture.

1764. Comet Seeker, on a stand, with horizontal and vertical motion, constructed by Professor Kaiser.

H. G. von Bakhuyzen, Director of the Observatory, Leyden.

The stand possesses the advantage that the eyepiece, which is fitted with a total reflecting prism, remains at the same height in all the positions of the telescope, whilst the axis of the eyepiece remains horizontal.

4554. Photograph of the Vertical or Zenith Telescope, for the observation of stars culminating near the zenith.

Prof. Lorenzo Respighi, Director of the Royal Observatory of the Campidoglio, Rome.

The vertical or zenith telescope is intended for the measurement of the zenith distance of stars culminating near the zenith, with the use only of the wire micrometer and mercurial horizon, without need either of inversion or level. The telescope being directed towards the nadir, on the reflecting horizon placed at a great distance below the object-glass, it is possible simultaneously to determine the nadir or the prime vertical with a fixed equatorial thread, and to collimate, with the movable thread, the reflected image of the stars that cross the meridian in the field of the telescope, and then to measure the zenith meridian distance with the micrometric screw. In order that the observation may be completely normal, it is necessary that the reflection of the stellar rays extend over the whole object-glass, which will be effected when the distance D of the reflecting horizon from the object-glass of the telescope satisfies the condition $D = \frac{A}{2 \tan Z}$, where A is the aperture of the object-glass, and Z the zenith distance of the star.

In Table VI. is photographically represented the zenith telescope of the Royal Observatory of the Campidoglio, constructed by Signor Ertel of Monaco, from a design given by Professor Respighi. The telescope is mounted as in transit instruments, and may also be used as a meridian telescope; the object-glass, made by Signor Merz, of Monaco, has a clear aperture of 0·108^{m}, with a focal distance 1·582^{m}. The micrometer is composed of 11 fixed equatorial threads and two movable threads, with a fixed meridian thread. The eye-piece can be moved with the greatest ease, whether in the meridian or vertically. The micrometer can be turned 90° to render the threads parallel to the meridian, and then the instrument serves as a transit-instrument.

1765. Four-inch Achromatic Telescope, on altazimuth stand, with quick and slow motions, in altitude and azimuth.

John Browning.

1766. Instrument for Easy Determination of Time by Equal Altitudes of Different Stars.

Colonel Zinger, Pulkowa.

This instrument is constructed for easy application of the method developed lately by Colonel Zinger for exact determination of time by equal altitudes of different stars (*see* Viertelgebrschrift des Astronomischen Gesellschaft, 1875). The principal condition is unaltered relation of level to telescope in going over from a star in the east to another in the west by having found its vertical axis. The divided circles serve only for setting the telescope. For using only bright and well determined stars down to the (3 or 4) magnitude, 9 minutes of time will be in the average sufficient to give time with the accuracy of 0·1^{s}. The eyepiece of the telescope is provided with a micrometer, to enable the observer to get with the same instrument, by approximately equal altitudes of two stars near the meridian, exact determination of latitude.

c. TRANSIT CIRCLES AND QUADRANTS.

1780. Model of the Greenwich Transit.

South Kensington Museum.

1767. Photograph of Meridian Circle, with object glass of 6″ aperture and 6′ focal length, circle of 2′ diameter; under construction for the Observatory of Strassburg.

A. Repsold and Sons, Hamburg.

In this instrument the microscopes are attached to the heads of the cast-iron columns, which also carry the bearings of the axis. One of the pivots contains an objective (2″ aperture), and the other a plate with a hole; this arrangement made at the suggestion of Prof. Winnecke, serves as a collimator for controlling the position of the axis. Perfectly central illumination of the field of view is effected by a small mirror at the back of the objective. The cells of the objective and eyepiece can be interchanged; there is an arrangement for Nadir observations, also for observations of the reflected image of a star, with a Nadir distance of 8°–60° by means of a movable mercurial horizon.

1768. Photograph of Transit Instrument, with azimuth circle and a broken telescope of 3″ aperture.

A. Repsold and Sons, Hamburg.

When the instrument is reversed, which can be very quickly effected, the level and lamp remain hanging, and the clamping-screw need not be loosened. There is a micrometer at the eyepiece.

1769. Photograph of Transit Instrument, with straight telescope of 3·3″ aperture. *A. Repsold and Sons, Hamburg.*

In reversing it is not necessary to loosen the clamping-screw, and the level remains in position. There is a micrometer at the eyepiece.

1770. Transit Instrument.

Prof. Dr. C. Bruhns, Leipzig, and August Lingke and Co., Freiberg.

The transit instrument is to be used in determination of time and of latitudes in the prime vertical.

The iron stand is on three feet, and can be set horizontal by means of two levels at right angles to each other. On the stand is a cradle with two supports to carry the telescope, which is always horizontal. There is an arrangement by which this cradle, together with the telescope, can be inverted. In order that the inversion may be as easy as possible, a spring is fixed below the stand, which comes into play when the telescope is inverted, and carries nearly the whole weight of the cradle and telescope. On one side of the cradle is a revolving pivot, which can be brought down between two screws, and according to the position of these screws can be turned through small angles. This movement in Azimuth enables observations to be made with the instrument, not only in the meridian, but also in a vertical arc through the polestar, and the index on the cradle which points to a division on the arc gives the position of the cradle in Azimuth. The graduation is so arranged that the interval between two lines gives about 10′, and can be read accurately up to whole minutes.

On the lower stand there is a boss with screws, and when the pivot of the cradle, which rests between the screws, is raised, and the screws at the same time loosened, the telescope can with ease be set in the prime vertical, and by the graduated scale the accurate position in the prime vertical can be read.

The telescope has an aperture of 73 mm., a focal distance of 80 cm., and two achromatic eyepieces, with magnifying powers of 60 times and 90 times, also two sun-glasses. The telescope is clamped at half its length, and the clamping apparatus is so arranged that the telescope suffers no pressure. Besides, there is at the middle point of the telescope a support with two screws, in order that the telescope may rest firmly when it is clamped: by this means it has a larger base. In front of the objective is a prism (made by Schröder, of Hamburg, who also supplied the objective) giving total reflection, and giving the same aperture as the objective. The prism is fastened by six screws on the hypothenuse surface against a strong spring; this spring is so strong that no turning of the prism can occur while alterations owing to change of temperature may take place. On one side there are also parts against which the prism is held by two strong screws on the opposite side. In the hypothenuse surface of the prism there is a dull spot through which the central illumination of the threads is effected. By a revolving arrangement the illumination can be regulated; this arrangement is particularly simple.

The telescope carries the head of the eye-piece, and as it can have only a horizontal direction, the eye-piece must remain always in the same position. A micrometer is attached to the eye-piece which can turn through 90°; this can be used to determine micrometrically the difference of the zenith distance of stars which have nearly the same north and south zenith distance.

There are garnets in the bed plates of the supports so as to lessen the friction. For turning the telescope there is a ring of gutta-percha. The telescope carries a level, which can remain permanently on it; one division of which = $1''\cdot43$. It has also an altitude arc graduated to 10′ and reading to 1′, by means of a vernier. The Nadir distance can be found by an artificial horizon. One division of the micrometer head = $\frac{1}{100}$th of a revolution, and the pitch of the screw is about $\frac{1}{100}$th of a Paris inch.

By this instrument can be determined—

1. The time on the meridian.
2. The time in the vertical of the Polestar.
3. When it is turned through 90°, the latitude, according to the method of Bessel.
4. The latitude, according to Talcott's method, where the difference between the north and south zenith distance is measured by the micrometer screw.

1771. Portable Catoptric Transit Instrument, with a telescope horizontally resting in collars, and revolving only on its own optic axis. Invented and constructed by C. A. Steinheil, sen^{r}.

Conservatorium of the Math. and Phys. Collections of Bavaria (Prof. Dr. Seidel).

The construction of this instrument is described by its inventor in *Schumachers Jahrbuch für* 1844 (Stuttgart and Tübingen, published by Cotta), p. 3, *et seq.*

1771a. Reflecting Transit Instrument.

W. Watson and Son.

In this the image of the star is received on a mirror, and then viewed by looking down through a small telescope placed in such a position as to be most convenient for observation; the telescope is stationary, but the mirror moving in the plane of the meridian, can be directed to any point in it, and observations taken without those inconvenient positions of the observer, so often necessary with transits of ordinary construction.

1775a. Arabic Quadrant in bronze, made by Ahmed Ibn Abd el Rahman. *Archæological Museum, Madrid.*

Its radius is $0\cdot21^{m}$. It has an inscription in Ensic letters of the latter end of the middle ages giving the name of the maker.

" Quadrant Orario " of Cosimo I. dei Medici, to the latitude of 43° 45′, made in Florence in 1566, probably by Ignazio Danti.

The Royal Institute of " Studii Superiori," Florence.

Interesting likewise, because it contains calculations relative to the reform of the calendar, afterwards carried out by Pope Gregory XIII.

" Quadrant Orario " to the latitude of 43° 45′, made in Florence in 1565 by Giovan. Battista Giusta.

The Royal Institute of " Studii Superiori," Florence.

" Instrumento del Primo Mobile " of Apiano, executed in Florence in 1568 by Ignazio Danti.

The Royal Institute of " Studii Superiori," Florence.

1772. Azimuth Quadrant, constructed by Metz in 1700.
H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

1722a. Davis' Quadrant or Back Staff. The first marine instrument for taking altitudes of the sun with reference to the visible horizon. This instrument was the prelude to Hadley's quadrant and the reflecting sextants and circles of the present day. The property of the Royal Astronomical Society, presented by R. J. Lecky. *Robert J. Lecky, F.R.A.S.*

1773. Astronomical Quadrant, said to have been the property of Napier of Merchiston, the inventor of logarithms.
University of Edinburgh.

The telescopes attached are evidently of much more recent and clumsy workmanship than the instrument itself. They are reported to have been added by a "college bailie" (in the days when the university was under the government of the town council), who fancied that he was thereby enhancing the value of his gift to the university.

1774. Quadrant, by Butterfield, of Paris.
Kew Committee of the Royal Society.

A brass quadrant, on a wrought-iron pedestal, carrying a telescope, with object glass ½ in. in diameter, and 2 ft. 3 ins. focal length. The quadrant is divided with a diagonal scale, and is provided with a case for hanging a plumb-line.

1775. Quadrant, formerly belonging to Tycho Brahe.
Royal Museum, Cassel (Director, Dr. Pinder).

This instrument is the astronomical quadrant of Tycho Brahe. The altitude quadrant, as well as the azimuth divided circle, are made of brass; the first is divided into sixths of a degree, the second into whole degrees, which can be read by a simple pointer, but without verniers. The radius of both circles is 40 cm., and the stand is constructed of cast iron.

1776. Two Quadrants, with double sights, old; the property of H.H. Prince Pless, Fürstenstein. *The Breslau Committee.*

1777. Quadrant, for the observation of the height of the sun, old; the property of H.H. Prince Pless, Fürstenstein.
The Breslau Committee.

1779. Small Semicircle, with double sights, for observing the heights of the sun, old; the property of H.H. Prince Pless, Fürstenstein. *The Breslau Committee.*

1777a. Quadrant, by Langlois. *Paris Observatory.*

1778. Pillar Sextant, on stand, with artificial horizon.
John Browning.

These instruments are intended for use in an observatory, or otherwise on land, for the purpose of obtaining accurate time.

1781. 12-inch Astronomical Quadrant, by Bird, employed in the observations of the transit of Venus.

Royal Society.

1782. Prismatic Circle, constructed in 1843, from the design of Professor Kaiser.

H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

By means of two observations the measurement of the angle can be obtained without any instrumental error, excepting those of division. Angles can be measured from 0° to 170°.

1783. Kaiser's Prismatic Circle, constructed on the same principles as the preceding. The construction of the stand, and of a few details, have been improved in this second model.

H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

d. EQUATORIALS.

1784. Equatorial Telescope by Abraham Sharp.

The Council of the Yorkshire Philosophical Society.

Abraham Sharp, eminent mathematician, mechanist, and astronomer, descended from an ancient family at Little Horton, near Bradford in Yorkshire, was born about 1651. He was apprenticed to a merchant at Manchester, but his genius led him strongly to the study of mathematics, both theoretical and practical. By the consent of his master, he quitted business and removed to Liverpool, where he studied mathematics, astronomy, &c., and where for a subsistence he opened a school, and taught writing and accounts. He had not been long at Liverpool when he fell in with a merchant from London, in whose house the astronomer, Flamsteed, then lodged. Sharp contracted an intimate friendship with Flamsteed, by whose interest and recommendation he obtained a more profitable employment in the dockyard at Chatham, where he continued till his friend and patron, knowing his great merit in astronomy and mechanics, called him to his assistance in contriving, adapting, and fitting up the astronomical apparatus in the Royal Observatory at Greenwich, which had been recently built, about 1676. He was principally employed in the construction of the mural arch, which in 14 months he finished, greatly to the satisfaction of Flamsteed. According to Smeaton this was the first good instrument of the kind, and Sharp the first artist who cut accurate divisions upon astronomical instruments. When it was constructed Flamsteed was 30, and Sharp 25 years of age. Sharp assisted Flamsteed also in making a catalogue of nearly 3,000 fixed stars, with their longitudes and magnitudes, their right ascensions and polar distances, with the variations of the same while they change their longitude by one degree. Among other indications of great genius, it was stated that Sharp made most of the tools used by joiners, clockmakers, opticians, and mathematical instrument makers. The telescopes he made use of were all of his own making, and the lenses were ground, figured, and adjusted with his own hands. He died July 18th, 1742, aged 91.

1784b. Gregorian Telescope, made by the celebrated John Hadley, A.D. 1726, and handed down in his family as being the first telescope of the kind ever made.
Cambridge Observatory, J. C. Adams, Director.

1787. Small Universal Equatorial, formerly belonging to the late Dr. W. H. Wollaston. *H. Wollaston Blake, F.R.S.*

1785. Eight and a half inch Reflecting Telescope, with parabolised silvered glass mirror. *John Browning.*

Equatorially mounted, with powerful driving clock, battery of improved achromatic eye-pieces, double prism solar eye-piece for observations of the Sun. Position micrometer, and new double image micrometer, with rotating hour circle, to facilitate finding objects without calculations.

1786. Four and a half inch Reflecting Telescope, with parabolised silvered glass mirror, on parallactic stand, for following the heavenly bodies with a single motion. *John Browning.*

This instrument was contrived for educational purposes; the mirrors are warranted to be of such quality as to bear well a power of 500 diameters.

1788. Equatorial, small, capable of carrying a telescope of 3 to 3½ inch aperture with perfect steadiness. *Yeates & Sons.*

1789. Photograph of Equatorial Mounting of a Refractor, of 9″ aperture and 13′ focal length, with micrometer and position-circle at the eyepiece. *A. Repsold and Sons, Hamburg.*

The declination circle can be read close to the eyepiece of the telescope; it is illuminated by the lamp which illuminates the cross-wires in the field of view of the telescope. By means of one perpendicular roller beneath the centre of gravity, the pressure of the hour axis on the bearings is removed. The clockwork is arranged in the head of the cast-iron column of which the foot is below the floor.

1790. Orbit-sweeper. Equatorial arrangement of a telescope of 6″ aperture, 8′ focal length, with third axis, 1874. Constructed for the Observatory of Strassburg. (Photograph.)
A. Repsold and Sons, Hamburg.

In this equatorial arrangement the head of the declination axis carrries at right angles the socket of a third axis, about which the telescope can be revolved, whilst its optic axis is inclined to the third axis at an angle of 90° ± 2°. By means of this arrangement a quickly moving celestial body can be easier found, as the third axis is directed to the pole of the projection of its orbit. (See G. B. Airy's observations on an "Orbit-sweeper," in the monthly notices of the R. Astron. Soc.) The telescope can also be placed parallel to the third axis at the head of the declination axis, and has then only an equatorial movement. This instrument is provided with clockwork, and has a changeable polar distance from 0° to 66°.

1791. Model of the Great Melbourne Reflector, completed by Messrs. Grubb & Son in 1868. Scale, ¾ inch to a foot ($\frac{1}{16}$). *Howard Grubb, F.R.A.S.*

Diameter of great mirror, 48 inches.
Focus, 30 feet 6 inches.
Form, Cassegrainian.
The ventilated tube formed of steel lattice bars.

Quick motion in declination	available from eye end of telescope.
Slow motion in declination	
Slow motion in RA	
Clamping in declination	

1792. Model of the Great Refracting Telescope, of 27 inches aperture, for the new Imperial Observatory at Vienna, now in course of construction at Mr. Howard Grubb's new Astronomical Works, Rathmines, Dublin. Scale, 1 inch to a foot ($\frac{1}{12}$th). *Howard Grubb, F.R.A.S.*

In this instrument the reading of all circles, right ascension as well as declination, is accomplished from eye end of great telescope.

Also quick motion in right ascension	All available from eye end of telescope.
„ quick motion in declination	
„ slow motion in right ascension	
„ slow motion in declination	
„ clamping in right ascension	
„ clamping in declination	

The one lamp hanging in end of declination axis illuminates—
Upper right ascension circle.
Declination circle on two opposite sides.
Bright and dark fields of micrometer.
Position circle of micrometer.
Field of 4-inch finder.

A second right ascension circle is available for reading from ground floor (south end), where also is a handle for quick setting, right ascension, and a sidereal clock face. The base of the instrument forms a chamber about 12 feet by 4½ feet, in which is contained the clock.

1792a. Model of Equatorial Mounting for the 3-ft. Reflector at Parsonstown, recently erected for the Earl of Rosse. *Earl of Rosse, F.R.S.*

1793. Photograph of a **Heliometer,** with object glass of 4″ aperture and 5′ focal length. This instrument was used by the Russian expedition for the observation of the transit of Venus, 1874. *A. Repsold and Sons, Hamburg.*

The telescope revolves in the head of the declination axis. The scales on both halves of the objective can be read by one microscope, of which the micrometer is close to the eyepiece of the telescope, and the same microscope serves to read the metal thermometer on the head of the objective. The slides of the objective move simultaneously on cylindrical surfaces in opposite directions. The position circle can be read and all the movements made close to the eyepiece. The instrument is mounted equatorially with changeable polar distance from 0° to 66°, and is moved by clockwork.

1794. Photograph of an Equatorial Refractor constructed for the Observatory in Düsseldorf. *Carl Bamberg, Berlin.*

e. EYE-PIECES.

1795. Eye-piece Shutter for Telescopes. Allowing the aperture to be opened and closed by turning the head of the eye-piece. *Captain J. E. Davis, R.N.*

This is effected by fitting the kidney-piece with a fulcrum pin and a lever, the latter passing through the side, which is acted on by the head being turned. It obviates the necessity of the slide or kidney-piece being fitted with a protruding pin, which frequently is the cause of breaking the nail, or (with gloves on) not being felt; the pin also often loosens, and drops out.

1796. Double-Image Micrometer or Eye-piece Heliometer. *C. A. Steinheil Sons, Munich.*

In this instrument the images are formed by means of two rectangular prisms, each of which revolves on an axis giving measurements by a micrometer screw. The prisms reflect at an angle of 45°, and are placed in a pencil of parallel rays of light. Thus when the reflecting surfaces form an angle with each other, the pencils of rays do not issue mutually distorted, as in other heliometers, but remain central at all angles; also the varying distance of the mirror from the plane of the image has no longer an influence on the definition of the images, which appear without parallax. A small telescope with its objective parallel to the axis of the telescope serves as eye-piece; it is placed parallel to the telescope axis. The relative illumination of the images changes with the distance of the greatest diameter from the field of view, in which the images respectively move. Any illumination which is taken away from one image is added to the other; the position-circle gives single minutes.

1796a. Zöllner Eye-piece, to be used as a star spectroscope for very small stars, and giving especially good definition.

A. Hilger.

f. MICROMETERS.

1797. Collection of the finest **Micrometer Screws,** of almost perfect accuracy, and a small instrument for observation.

Hugo Schröder, Hamburg.

This apparatus serves for the examination of micrometer screws; those exhibited are shown as examples of the great accuracy and delicacy which can be attained by cutting the screws according to the method invented by Hugo Schröder. A table showing the results of the examination of one of the screws by Dr. Vogel is subjoined.

1797a. Collection of Micrometer Screws, cut with Hilger's special apparatus, for astronomical purposes.

40 threads to the inch (1).
100 „ „ (2).
200 „ „ (1).
1,000 „ „ (1).

A. Hilger.

1798. Position Micrometer, constructed for the refractor of the Royal Observatory at Berlin. *Carl Bamberg, Berlin.*

1799. Four Micrometers, for Astronomical Telescopes.
F. W. Breithaupt and Son, Cassel.

Micrometer divisions on glass, for different kinds of astronomical observation. The one with circular divisions was used by Prof. Spörer, of Anclam, for the observation of the solar prominences at Aden during the total solar eclipse.

1800. Electro-magnetic Registering Apparatus.
M. Th. Edelmann, Physico-Mechanical Institute, Munich.

1800a. Stereo-Micrometer. Apparatus used with binocular telescopes, and measuring both angles and distances, for geodetic and astronomical measurements. Both eyes being employed, one measuring, the other observing, position and distance are thus given simultaneously. With stereo-micrometrical photographs of landscapes. *Prof. Carl Wenzel Zenger, Prague.*

1800b. Positive Eye-piece, with a bright line micrometer, invented by the exhibitor for the purpose of making measurements in the dark. *A. Hilger.*

II.—INSTRUMENTS FOR DETERMINING THE MOLECULAR STRUCTURE OF THE HEAVENLY BODIES.

a. SPECTROSCOPES.

1801. Spectroscope of Donati, which served him in the observations of the eclipse of the sun, made in Agosta (Sicily) the 20th of December 1870.
The Royal Institute of " Studii Superiori," Florence.

With the aid of this spectroscope Donati was able, during the eclipse, to observe the luminous lines of hydrogen. He afterwards constructed a second one, composed of 25 prisms of very great dispersive power. His premature death, however, robbed science of the important observations which would certainly have resulted from so perfect an instrument.

1802. Amateurs' Star Spectroscope. *John Browning.*

This instrument will show the lines in the spectra of stars of the second magnitude, when used with an object-glass only 3 in. in diameter. By detaching the cylindrical lens, the instrument may be used as a small direct vision spectroscope.

1803. Spectrum Apparatus, for the observation of the spectra of the fixed stars, planets, and nebulæ; arranged after the spectrum apparatus of Boshkamper (belonging to the Observatory of Hamburg). *Hugo Schröder, Hamburg.*

The spectrum apparatus is constructed on the simple principle which has proved so successful at the Observatory of Bothcamp, with the difference, however, that this apparatus is arranged for absolute measurement, and that the one at the Observatory of Hamburg is attached at right angles to the principal axis of the refractor.

1804. Spectrum Apparatus, for observing the **Solar Prominences,** to be attached to the collimator of the spectroscope.

Hugo Schröder, Hamburg.

This spectrum apparatus, which is in reality a supplement of the first, can be fastened to the collimator of the other one with great readiness. The object of this apparatus is the observation and measurement of the solar spectrum as well as of the solar prominences. The principle on which it is constructed differs from that of the former in that the rays after once passing through the system of prisms do not issue from it in the same direction as they entered, but are refracted and dispersed by the heavy prisms of flint glass. By means of a rectangular prism of crown glass the rays are compelled to pass through the system a second time, and leave it in a direction parallel to that of their first entrance. By a second prism of crown glass the rays are reflected into the observing tube which is attached to the prism holder. The movement of the spectrum across the field of view, as well as the absolute measurement, is effected by turning the first prism of crown glass by means of the micrometer screw. This apparatus is, on account of its convenient and highly stable construction, particularly to be recommended for observers who have scanty room at their disposition, and yet wish to undertake accurate measurements.

1805. Star Spectroscope, after Dr. H. C. Vogel (described in the Berichte der königlichen sächsischen Gesellschaft der Wissenschaften, December 1873). *H. Heustreu, Kiel.*

This apparatus recommends itself for its simple construction, its varied application to all kinds of observations, and its reasonable price.

1806. Spectroscope made by Merz in Munich.

Prof. Dr. Winnecke, Strassburg.

1806a. Parts of a Solar Spectroscope, made by Elliott Brothers in 1869. *J. Norman Lockyer, F.R.S.*

In this instrument the prisms are brought to minimum deviation by means of a spring, suggested by Mr. G. W. Hemming, and the light is brought back through the prisms by a total reflection prism at the end of the train, on the plan first employed, it is believed, in this instrument, and suggested by the exhibitor.

1806b. Solar Spectroscope, with diffraction grating on speculum metal, presented to the exhibitor by Mr. Rutherfurd, of New York. *J. Norman Lockyer, F.R.S.*

1806c. Solar Spectroscope, used since 1868 in observing solar phenomena, made by Browning.

J. Norman Lockyer, F.R.S.

1806d. Slit arrangements for Spectroscopes.

J. Norman Lockyer.

1806e. Photographs of Hilger's Stellar and Solar Spectroscope. *A. Hilger.*

4552. Photographs representing various Scientific Instruments in the Observatory of the Collegio Romano, Rome.

Padre Secchi, Director, Rome.

No. 1. Spectroscope applied to the refractor of Merz, provided with a network by Rutherford.

No. 2. Spectroscope with network, applied to the refractor of Merz, with the cover adapted to the plate of the network.

No. 3. Spectroscope with five prisms, with double passage of the ray by reflection, and with automatic movement to bring within the eyepiece the various dispersed rays.

No. 4. Spectroscope with three angular prisms, and one with direct vision, enclosed in the collimator.

No. 5. Large objective prism of Merz, of 6 inches, for the spectrum analysis of the stars.

No. 6. Meteorograph of Padre Secchi.

No. 7. Curves traced with the meteorograph.

4555. Photographs representing the Daily Drawings of the Solar Chromosphere, made by the spectroscope of Professor Lorenzo Respighi.

Prof. Lorenzo Respighi, Director of the Royal Observatory of the Campidoglio, Rome.

On the 26th October 1869, at the Observatory of the Campidoglio, the spectroscopic observation and the daily representation of the chromosphere on the solar horizon were for the first time undertaken, and this work has been regularly continued up to the present time. The instrument used in these observations is an equatorial by Merz, with telescope of 4½ inches aperture, to which is applied a spectroscope with direct vision, by Hoffmann, with five prisms, with circle of position to fix the place of the various parts of the chromosphere and of the protuberances. Notwithstanding the small dimensions of the instrument and the moderate dispersion of the spectroscope, the chromosphere and the protuberances are clearly exhibited even in their smallest details.

The Photographs I., II., III., IV., and V. represent 140 drawings of the chromosphere made with this apparatus by Professor L. Respighi.

d. STELLAR PHOTOMETRY.

1807. Astronomical Photometer. Designed by Professor Thury.

Geneva Association for the Construction of Scientific Instruments.

The apparent brightness of a heavenly body seen in the telescope is gradually reduced by the movable diaphragm placed before the objective, and if necessary by the interposition of one or two dark mirrors placed behind the eyepiece in the square box, which is exposed with the diaphragm. The light is gradually reduced until the object is no longer visible. The aperture of the diaphragm is then shown upon a dial placed under the eye of the observer.

The full description of this apparatus is to be found in the "Archives des Sciences physiques et naturelles de Genève," 1874.

1808. Zöllner's Astrophotometer, for measuring the light of the heavenly bodies by comparison with that emitted by the brightest portion of the flame of a paraffin lamp.

Earl of Rosse, F.R.S.

The accuracy of the work done with this instrument depends on the fact that, though the total light emitted by the flame varies with its size, the *intensity* of the brightest part is appreciably constant. Two artificial stars are formed by means of a pin hole, a double concave lens, and a double convex lens, which appear in the field by reflexion from front and back faces of a plate of glass alongside of the image of the real star whose light passes through the plate. The intensity of the artificial star is varied, first by changing the pin hole, and finally by two Nicol's prisms, the colour being first matched with that of the star by means of a third Nicol, with a quartz plate between it and the first of the other two Nicols. The instrument is provided with object glasses of various sizes (and diaphragms) up to 2¾ inches, and, if fainter stars are to be examined, can be screwed on to the eyepiece of an equatorial instrument. A second arrangement, like the first, but without the quartz plate arrangement, forms an artificial star from moonlight, for comparison of the light of that body with the artificial star.

896. Photometer, constructed by Schwerd for the Observatory of Pulkowa. *The Imperial Observatory, Pulkowa.*

In agreement with Prof. Argelander and M. Otto Struve, the late Prof. Schwerd of Speyer constructed, in 1863, four photometers of the same size, two for Russia (Pulkowa and Wilna), the third for the Observatory, Bonn, the fourth for his own use. The principle of the construction is that of comparing the light of different stars exhibited in the same field by telescopes of different aperture. The diameter of the diaphragms to be applied to the two object-glasses, and corresponding systems of lenses, for purpose of producing equal light and colour, gives the measure of the relative brightness. The two telescopes, one of 2·3 in. aperture and 4 ft. focal length, the other of 1·2 in. aperture and 2 ft. focal length, are parallactically mounted and moved together by the same clockwork (which is not exhibited), so that the images of the two stars keep constantly the same place in the field during observation. Being worked out in all parts with greatest care and on sound optical principles, it can hardly be doubted that this instrument perfectly answers its purpose; but on account of the great number of constants to be determined for it, its use is rather difficult. Until now only two of these instruments have been practically applied, that of Schwerd himself, and the one constructed for Wilna. In both cases the first problem has been the determination of the co-efficient of extinction of light by the atmosphere of the earth.

1809. Astrometer for Reflecting Telescopes, invented by the contributor. *E. B. Knobel.*

This instrument has been invented for determining the magnitudes of stars on the principle of limiting apertures. It consists of an equilateral triangular aperture, constructed of two plates, one forming the base and the other the opposite angle of the triangle, connected by a screw shaft of peculiar construction. The upper portion carrying the angle plate, being a *right handed*, and the lower connected to the base plate, a *left handed* screw. The pitch of the upper screw is *twice* that of the lower. By simply turning the milled head at the end of the shaft, the aperture is made smaller or larger within the limits of the triangle inscribed in the telescope tube, and zero. The instrument depending on the mathematical principle sin $30^\circ = \frac{1}{2}$ the aperture is thus always accurately equilateral, and concentric with the mirror or object glass. The graduated base and the micrometer head give the side of the triangle, whence the aperture is readily obtained.

1810. Astro-Photometer, according to Glan's system.
Schmidt and Haensch, Berlin.

III.—OBJECTS ILLUSTRATING THE HISTORY OF THE TELESCOPE AND ASTRONOMICAL OBSERVATION.

1811. Galileo's Telescope. Object-glass, 50 mm. in diameter ; eye-glass, plano-concave, 23 mm. in diameter. It served for the most important discoveries and experiments of Galileo, and was constructed by himself.
The Royal Institute of "Studii Superiori," Florence.

1814. Galileo's Telescope. Object-glass, 38 mm. in diameter; eye-glass, double concave, 19 mm. in diameter; made by Galileo.
The Royal Institute of "Studii Superiori," Florence.

1815. Object Glass of the diameter of 40 mm., **made by Galileo,** and with which he discovered the satellites of Jupiter on the 9th of January 1610, and first saw the spots on the sun. Having been broken, it was presented by Viviani to Prince Leopoldo dei Medici, who placed it in a frame finely wrought in ivory, with inscriptions.
The Royal Institute of "Studii Superiori," Florence.

Galileo's part in the invention of the telescope, and the merit due to him, clearly appears from the following extract of the answer given by him, in the "Saggiatore," to Padre Orazio Grassi, a Jesuit. "The share of credit that " may be due to me in the invention of this instrument (the telescope) and " whether I can reasonably claim it as my own offspring, I have expressed in " my 'Avviso Sidereo,' which I wrote in Venice. I happened to be there when " the news reached me that a Dutchman had presented Count Maurice with a " glass, by means of which things far away appeared just as clearly as if they " were quite close at hand, but without any detail being mentioned. Upon " hearing this, I returned to Padua, where I was then living, and pondered over " this problem, and the first night after my return I found it out. The following " day I made the instrument. After that I immediately set to work to make " a more perfect one, which being completed six days afterwards, I took to " Venice, where so great a marvel attracted the attention of almost all the " principal gentlemen of that republic. Finally, by the advice of one of my " dearest patrons, I presented it to the prince in presence of the college. The " gratitude with which it was received, and the esteem in which it was held, " are proved by the ducal letters which I have still preserved, since they bear " witness to the generosity of His Serene Highness in confirming me for life in " my lectureship of the studio of Padua, with double the payment of that which " I had had beforehand, which in its turn was more than three times what

" any of my predecessors had enjoyed. These facts, Sig. Sarsi, did not take " place in a forest or in a desert, they occurred at Venice, and if you had " been there then you would not have put me down simply as a foster-parent " of the invention. But perhaps some one may tell me that it is no small " help towards the discovery or solution of any problem to be first of all " apprised in one way or another of the truth of its conclusion, and to know " for certain that it is not an impossibility that is being sought after; and " that, therefore, the information and the certainty that the telescope had " already been made, were of such use to me, that in all probability I should " never have made the discovery without them. To this I answer that the " help given me by the information I received, undoubtedly awoke in me " the determination to apply my mind to this subject, and that without it " I should very likely never have turned my thoughts in that direction; but " besides this, that I cannot believe that the notice I had had could in any " way render the invention easier; and I say moreover, that to find the " solution of a problem already thought out and expressed requires far greater " genius than to discover one not previously thought of; for in the latter " case chance can play a great part, while the former is entirely the work of " reasoning. We know that the Dutchman, the first inventor of telescopes, " was simply a common spectacle-maker, who, handling by chance glasses of " various kinds, happened at the same moment to look through two, the one " concave, the other convex, placed at different distances from his eyes, and " in this manner he observed the effect which was produced, and thus invented " the instrument; but I, warned by the aforesaid notice, came to the same " conclusion by dint of reasoning; and since it is by no means difficult to " follow, I should like to lay it before you. This, then, was my reasoning; " this instrument must either consist of one glass only, or of more than one " glass, it cannot be of one alone, because its figure must either be convex, or " concave, or comprised between two parallel superficies, but neither of " these shapes alters in the least the objects seen whilst increasing or " diminishing them, for it is true that the concave glass diminishes, and that " the convex one increases them; but both show them very indistinctly, hence " one glass is not sufficient to produce the required effect. Passing on to " two glasses, and knowing that the glass of parallel superficies has no " effect at all, I concluded therefore, that the desired result could not possibly " follow by adding this one to either of the other two. Hence, I restricted " my experiments to combinations of the other two glasses, and I saw how " this brought me to the result. Such was the progress of my discovery, in " which you see of how much avail was the knowledge of the truth of the " conclusion. But Sig. Sarsi, or others, believe that the certainty of the " result affords great help in producing it and carrying it into effect. Let " them read history and they will find that Archites made a dove that could " fly, and that Archimedes made a mirror that burned at great distances, and " other admirable machines; now by reasoning on these, they will be able " with very little trouble, and very great honour and advantage, to discover their " construction, but even if they do not succeed, they will derive the benefit of " being able to certify themselves that the ease of fabrication which they " promised themselves from the pre-knowledge of the true result was much " less than they had imagined."

We must add that many of the principal persons in Europe were anxious to have Galileo's telescopes, and that he sent presents of them to the Grand Duke of Tuscany, to Prince D. Antonio de' Medici, the Elector of Bavaria, the Emperor Mathias, Cardinal Borghese, the Queen of France, the King of Spain, the King of Poland, the Landgrave of Hesse, Giuliano de' Medici, Cardinal Del Monte, Cardinal Montalto, to the Dukes of Acerenza and of Acquairva, &c., &c.; he also sent some to Holland, whence Constantine

Huygens writes in 1637, that it was impossible to find artificers in that country having skill enough to make telescopes of sufficient power to observe the satellites of Jupiter.

The principal discoveries made by Galileo by means of his telescope in chronological order, are as follows:—

He first of all observed the cause of the lunar spots, recognising in them the effect of shade produced by the heights which must exist upon the Moon, and thus proving that it was covered with mountains and table-lands; and he pointed out the way for determining their heights. He likewise perceived that the secondary light transmitted to us from the Moon proceeds from the reflection of the solar rays from the suface of the earth to that of the Moon.

Directing his telescope towards the Milky Way he was the first to certify the fact that it was composed of myriads of stars.

On the 3rd of January 1610, he discovered that three secondary planets revolve round Jupiter, and on the 13th of the same month he found the fourth. He named these satellites the "Stelle Medicee." He showed that they, in revolving round Jupiter, underwent eclipses, just as our moon does. He determined the length of their rotations, remarking that by their means it is possible to observe 1,000 eclipses a year, which would be of great utility for finding the longitude of any place.

In the month of August 1610, whilst observing Saturn, he noticed that it appeared to be continually accompanied by two planets which touched it at the extremities of the same diameter, so that he called it *tricorporeal*.

In the same month he first saw the spots on the Sun, determined the direction of their motion, and, with happy intuition, compared them to terrestrial clouds.

On the 30th September 1610 he found that Venus changed figure like the Moon, so he called it *horned* (*la falcata*).

He likewise observed Mars and its phases, and reasoned admirably upon the comets.

Taking his stand upon these astronomical observations, Galileo embraced, maintained, and defended the system of Copernicus, so that he had to undergo the cruel persecutions of Rome, which compelled him to utter that recantation, at the end of which he broke out into the now celebrated exclamation, "*Eppur si muove!*"

1816. Telescope of Torricelli, with an object-glass of 50mm. in diameter; eye-glass, plano-convex, 22mm. in diameter.

The Royal Institute of "Studii Superiori," Florence.

Torricelli was the first who set himself the task of solving the optical problem of finding the proper shape to be given to the surfaces of the glasses used for telescopes. After many months of study and hard work, as he himself relates, he succeeded in his object and the resnlt was fully confirmed by experience. He did not make his lenses on metallic forms or moulds, but fixed them on pieces of slate with a cold mixture, in order to obviate the defects caused by the change of shape which the glasses undergo when warmed. To him we also owe the microscope formed of one lens, or rather of a little glass ball, which worked with a lamp.

1818. Day Telescope of Divini, from S. Severino. The diameter of the object-glass is 70mm.; the diameter of the first eye-glass and of the second lens, double-convex, 33mm. The third lens is wanting.

The Royal Institute of "Studii Superiori," Florence.

Divini constructed telescopes between the years 1646 and 1668, and even made some of the length of 72 palmi Romani.

1819. Day Telescope of Ippolito Mariani, a Florentine, surnamed *il Tordo;* first practical optician; taught by Galileo. Object-glass, 103 mm. in diameter. The eye-glass is composed of two lenses, plano-convex, of mm. 48 in diameter. The second and third lenses are similar to the eye-glass.

The Royal Institute of "Studii Superiori," Florence.

1820. Day Telescope of Campani, romano, object-glass 47 mm. in diameter; eye-glass, double convex, 27 mm. in diameter; second and third lenses the same.

The Royal Institute of "Studii Superiori," Florence.

Campani's well known telescopes are to be found in many observatories; some of them are 70, 100, 150, and even 210 palmi Romani in length.

1821. Telescope by Amici.

The Royal Institute of "Studii Superiori," Florence.

1830. Volume, Experiments in Natural Science Accademia del Cimento.

The Royal Institute of "Studii Superiori," Florence.

1831. Telescope, by Chr. Huygens. The objective ground and polished by him, and bearing his signature.

Prof. Dr. P. L. Rijke, Leyden.

Its focal distance is 3·906 m., and aperture 0·0616 m. The eyepiece is composed of three convex lenses. The lens *a*, the nearest to the objective, and the lens *b*, following it, have a focal distance of 0·105 m., and an aperture of 0·04; the lens *c* has a focal distance of 0·079 and an aperture of 0·038 m. The distance between *a* and *b* is 0·212 m.; that between *b* and *c* 0·182 m. The eye should be placed at a distance of 0·058 from the lens *c*. The lenses *b* and *c* serve only to rectify the images.

1831b. Telescope by Campani.

Royal Museum, Cassel (Director, Dr. Pinder).

The tube is wood; it measures, when drawn out, 16 feet. This was bought in Rome by Landgrave *Charles.*

1831g. Two Telescopes (Achromatic), made by Dollond, about 1765, for the Russian expeditions for the observation of the transit of Venus in 1769.

The Imperial Academy of Sciences, St. Petersburg.

Object-glasses of 3·6″ and 2·8″ aperture, focal length 11·2′ and 8·5′. There are several of each size in possession of the Academy. As they are not designated by numbers or other distinct marks, it cannot exactly be made out which of them has been used by the different observers.

1832. Terrestrial Refractor, made by Van Deyl, at Amsterdam, in the year 1781. *Teyler Foundation, Haarlem.*

1831a. Huygens' Aërial Telescope. *Royal Society.*

1831b. Object-Glass by Huygens, 170 feet focal length. *Royal Society.*

1831c. Object-Glass by Huygens. *Royal Society.*

1831d. Object-Glass, Venetian, of 90 feet focal length.
Royal Society.

1831e. Original Reflecting Telescope, made by Sir Isaac Newton. *Royal Society.*

1833. The Herschel 7-foot Telescope. The original instrument constructed by Sir W. Herschel.
Royal Astronomical Society.

The tube is 7 inches in diameter and 7 feet long. Both mirrors were finished by Sir W. Herschel's own hands; they are sound and whole, but are much tarnished, and the large mirror was damaged in a fire some years since. The framework of the stand is entire, but the moving screws, cords, &c. are useless in their present condition.

1784a. Newtonian Telescope, belonging to Sir W. Herschel, and used by him while living in Bath. He is said to have discovered the planet Uranus by its means. Focus, 7 feet; diameter of speculum, 6⅛ inch. *Edwin Smith.*

This telescope was purchased at Sir W. Watson's sale, Pulteney Street, Bath, about 1860. It had apparently remained after Sir W. Watson's death for some time in a lumber room of the house, and when purchased by Mr. E. Smith a paper of directions for the use of the different eyepieces was discovered in the drawer of the stand.

A portrait in oil of Sir W. Herschel, in one of the rooms of the same house, was sold at the same time. Dr. Brabant, of Marlborough Buildings in this city, who was a great friend of Sir W. Herschel, has often called on Mr. Smith to see the telescope, and repeatedly declared to him that this was the same instrument by which the planet Uranus had been discovered in 1781. It is supposed to have been made by Sir W. Herschel, while organist in the Octagon Chapel, Bath.

1834. 10-ft. Newtonian Reflecting Telescope by Sir William Herschel, with 8½ inch large mirror, small plane reflecting mirror, and several eye-pieces of various powers.
Rev. Robert Main, Director of the Radcliffe Observatory, Oxford.

This telescope was made by Sir William Herschel for the Radcliffe Observatory in the year 1812, and was received at the Observatory in April 1813; Sir William himself having come to Oxford to superintend the mounting and the adjustments of the mirror.

The correspondence with Dr. Robertson, who was then Radcliffe Observer, is preserved at the Observatory.

1834a. Eight plans of the Telescope, made in London at the end of the last century, under the direction of Sir William Herschel, for the Royal Observatory at Madrid.
Astronomical Observatory, Madrid.

These plans give an exact idea of all the details of the instrument and mounting.

The speculum was of 2 feet aperture and 25 feet focal length.

This instrument was sent from London in 1801, and set up at Madrid in 1804. Four years afterwards the French converted the observatory into a fort, the telescope was destroyed, the only part remaining being the speculum.

1836a. Small Hand Speculum Polishing Machine, constructed and used by Sir William Herschel to polish specula of

7 feet focus (6 in. aperture). Smaller machines for smaller specula were made of this construction, and are in part preserved. The polishing machines used to figure and polish large specula (18 in. and 49 in. diameter) for the 20 foot and 40 foot telescopes used at Slough and at the Cape of Good Hope appear to have been of the same construction as this instrument and of proportionally larger size. *Prof. A. S. Herschel.*

1836b. Brass foot used in place of the lead block to carry the furrowed pitch rubber or polisher revolving with the bed plate of the machine, to whose centre it is fastened down by screws. For the larger sized mirrors these brass plates were used as well as for smaller sizes to replace the lead foundation or bearer of the pitch, and some 18 in. ones besides this small one are preserved. *Prof. A. S. Herschel.*

1836. Compound Speculum, of 2 feet aperture. *Earl of Rosse, F.R.S.*

This is one of the earlier attempts of the late Earl of Rosse to construct specula of considerable dimensions of the hardest and most reflective quality of speculum metal.

To avoid the difficulty of casting the mirror in one, a cubical block of speculum metal was sawed into laminæ, and these were laid side by side on a ribbed backing of a zinc-copper alloy of the same co-efficient of expansion, whose surface had been previously tinned; the whole was carefully brought up to the melting point of tin, and melted tin applied to unite the whole. Though superior in rigidity to the solid metal speculum afterwards successfully constructed, it was discarded in favour of the latter, owing to the injury to definition through diffraction at the junctions of the laminæ.*

1836aa. Speculum (Experimental), with Annulus separate from Central Portion. *Earl of Rosse, F.R.S.*

Constructed for the purpose of attempting to correct spherical aberration by advancing the annulus before it had been shown to be possible to produce a paraboloid figure. Given up in favour of the *solid* speculum for same reason as the last (diffraction).

1835. Discs of Optical Glass for Refracting Equatorial:
1 Hard crown.
1 Dense flint. *Chance Brothers & Co.*

1835a. Series of seven Glass Parabolic Mirrors, from $3\frac{1}{2}$ in. to 15 in. in diameter, from 2 ft. to 10 ft. focus, silvered on the surfaces by Liebig's process. *John Browning.*

1836c. Achromatic Telescope with Rochon's Prysmatic Micrometer (in its main tube) with vernier reading to 1″, formerly belonging to the Rev. Dr. Peacock, F.R.S., Treasurer to the Royal Astronomical Society, and probably the identical instrument used by the late Mr. Francis Baily, F.R.S., &c., in his observations of the Solar Eclipse of September 20, 1820. *William Lawton.*

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* N.B.—Another compound speculum of 3-foot aperture is still preserved, but the smaller one is sent, as the weight of the other is considerable.

1836d. Small Gregorian Telescope, maker unknown, formerly the property of the late Dowager Viscountess Midleton, date about 1750. *Hon. Miss Brodrick.*

1853. Complete Transit of Venus Astronomical Equipment, as used by the English expeditions.

The Astronomer Royal.

1853a. One of the Telescopes used in the "Transit of Venus" Expedition.

The French Commission for Observing the Transit of Venus in 1874.

EYE-PIECES AND OBJECTIVES.

1837. Objectives and Eye-pieces of the 17th and 18th centuries, the greater part of which were ground and polished by Christian and Constantine Huygens.

Prof. Dr. P. L. Rijke, Leyden.

No. 1.	Objective of	120 ft.	Bearing the signature of Const. Huygens.
No. 2.	,,	84 ,,	
No. 3.	,,	85 ,,	
No. 4.	,,	43 ,, 7 in.	
No. 5.	,,	43 ,,	
Nos. 6 & 7.	,,	34 ,, each	
No. 8.	,,	34 ,,	Bearing the name of Chr. Huygens.
No. 9.	,,	34 ,,	Bearing the signature of Chr. Huygens.
No. 10.	,,	10 ft. 8 in.	Bearing the name of Chr. Huygens.
No. 11.	Bearing the name of Hartsoeker.		
No. 12.	Objective of	32 ft.	Bearing the signature of Marcell.
Nos. 1*a* and *b*.	Eye-pieces of	$7\frac{1}{2}$ and 8 inch,	to use with objective No. 1.
No. 2*a*.	,,	6	,, ,, ,, ,, 2.
No. 5*a*.	,,	$4\frac{1}{2}$	,, ,, ,, ,, 5.
No. 7*a*.	,,	$3\frac{5}{8}$	,, ,, ,, ,, 7.
No. 8*a*.	,,	3	,, ,, ,, ,, 8.
No. 10*a*.	,,	2	,, ,, ,, ,, 10.

1838. Photograph of the **Lens** by which **Huygens** discovered **Saturn's Ring.** *Prof. Buys-Ballot, Utrecht.*

This lens is stated to be the same by which Christian Huygens made out Saturn to be surrounded by a ring. It bears the inscription "X. 3 FEBR. " ƆDCLV (Febr. 1655), Admovere oculis distantia sidera nostris."

1838a. Two large Objective Glasses mounted on brass.

M. Evrard, Paris.

1840. Metal for a Newtonian Reflector, with several wooden eyepieces, but without tube or mounting, by Hadley.

Royal Society.

IV.—APPARATUS FOR DETERMINING THE EARTH'S MOTION AND DENSITY, &c.

1841. Apparatus used by Baily in repeating the Cavendish Experiment. *Royal Astronomical Society.*

Of this apparatus several parts were missing, but have been lately restored. The original portions are the long mahogany box with glazed ends for the torsion balance, and upright column in the middle for the suspension wires, and a box containing three small leaden, one brass, and two ivory balls, two brass cylinders, and one leaden lenticular weight. A full description of the apparatus will be found in the Memoirs of the Royal Astronomical Society, Vol. XIV.

1842. Gauss's Pendulum for demonstrating the rotation of the earth, executed in the year 1853 by Dr. Meyerstein.

Geodetic Institute of the Observatory at Göttingen (*Prof. Dr. Schering, Director*).

1878. Sphere bearing traces of M. Foucault's observations on the Rotatory motion of the Earth.

Conservatoire des Arts et Métiers, Paris.

V.—ASTRONOMICAL CLOCKS AND SUNDIALS.

1843. Astronomical Clock, with Sir G. B. Airy's Barometric Compensation. *E. Dent and Co.*

This clock has been fitted up with a Graham escapement; it is in other respects almost a counterpart of the new standard clock of the Royal Observatory, Greenwich.

It is found that the tendency of a clock is to lose with a high barometer, and gain with a low one. Compensation is effected in this way: there is a lever, one arm of which carries a float resting on the surface of the mercury in the cistern of a barometer tube; the other arm carries a horseshoe magnet which faces the opposite poles of two bar magnets fastened to the pendulum bob. When the barometer rises the mercury in the cistern is depressed, so that the arm of the lever carrying the float falls whilst the other arm rises, thus bringing the horseshoe magnet closer to the bar magnets; when the barometer falls the same action takes place in the opposite direction, thus increasing or diminishing a force acting in the same direction as gravity.

1843a. Three different Forms of Dipleidoscope.

E. Dent and Co.

1. The simple form consists of two mirrors placed at an angle of about 60° and in front of them a plain unsilvered glass, the whole combination being mounted, for the sake of conveniently taking observations, in a small cast metal pyramid. The optical arrangement operates in this way. Rays from the sun fall upon the front glass, and part are reflected from it and form an image; but the remaining part pass on, and meeting first one and then the other mirror, are reflected back through the front glass, and form a second image. The instrument is to be placed so that these images shall appear together in the field of view, a minute or two before apparent noon. Then what is seen is this: as the sun advances to the meridian the two images will approach, they will touch, and gradually cover one another (this observation gives the instant of apparent noon); they will continue to move on, and will finally leave one another; and each of the observations of contact, superimposition, and parting contact will be each separately and together available for determining true time. The base-plate which accompanies the instrument, it is intended should be fastened out of doors, in such a position that its guide bar shall give the right direction to the small metal pyramid.

2. The mural form. This instrument only differs from the preceding in its method of mounting, which secures greater accuracy; and a small telescope is added, for the purpose of obtaining a finer reading of all the observations.

(One of these instruments is mounted upon the balcony outside. Upon looking into the telescope (which must be shifted up or down until the images are seen) the two apparent suns will be visible in the field of view; these will gradually approach as above described, and will be superimposed at the instant of apparent noon.)

3. The universal form. This is mounted upon an axis, which by means of a divided "latitude" scale can be placed parallel to the earth's axis. It has also another scale, divided from three hours before, to three hours after noon, and true time may be obtained at any quarter of an hour within this interval. The instrument is furnished with a compass, but this should not be used where more accurate methods of setting it can be employed.

1843b. Astronomical Signaller for the purpose of giving notice of the approach of stars, or any required point in R.A. to the meridian. *E. Dent and Co.*

1844. System of Patent Electro-Sympathetic Clocks.
James Ritchie and Son.

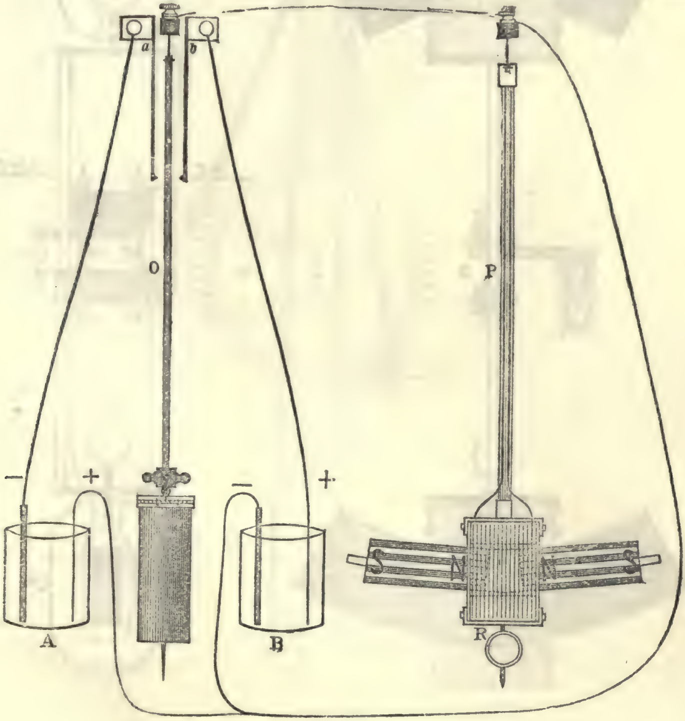


Fig. A.

These consist of—

1st. An ordinary clock, requiring periodical winding, to serve as a normal or motor clock for the system.

Wires from the reverse poles of two galvanic batteries are connected with slender insulated springs, so placed that the pendulum in vibrating touches each alternately, and transmits through the pendulum rod reverse currents to the line wire and subsidiary clocks.

This arrangement may be seen through the glass sides of the clock-case, and in Fig. A.

2nd. Electro-sympathetic clock. The pendulum consists of a coil of insulated copper wire. Within the coil (which forms the ball or bob) a double cluster of magnets, having their similar poles slightly separated, is fixed to the casing of the clock. The currents from the motor clock passing through the wire coil cause it to be alternately attracted and repelled by the magnets,

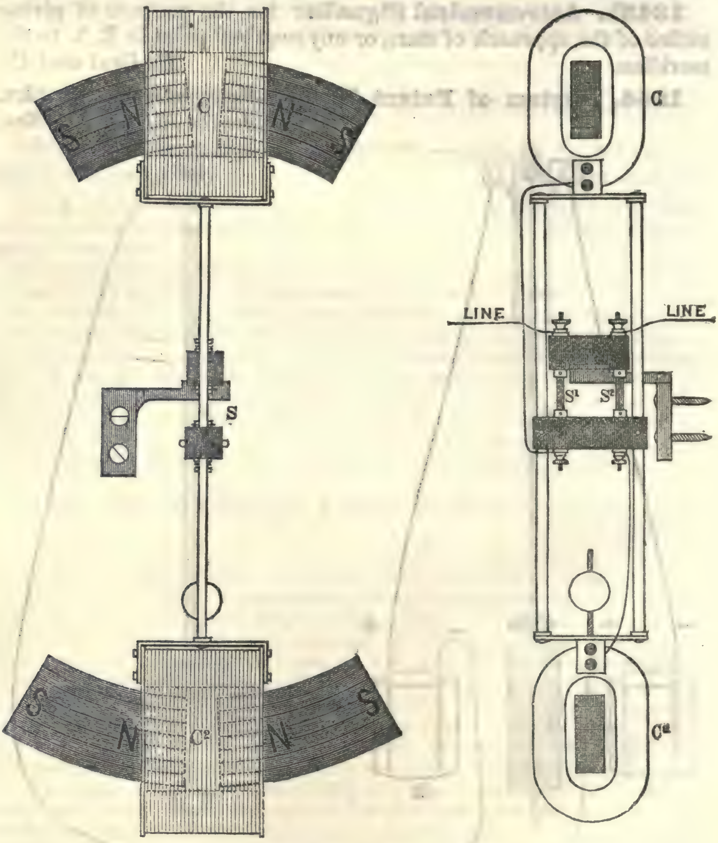


Fig. B.

thereby giving motion to the pendulum, and maintaining it in vibration. The connexions between the batteries and motor and sympathetic clock pendulums with the position of magnets are shown in Fig. A.

3rd. The sympathetic pendulum is also made with an ordinary ball or bob, carrying a single bar magnet passing into small coils of wire fixed to the case and placed in circuit with motor clock, as shown in the square case.

4th. To admit of a pendulum vibrating seconds being introduced within the limits of the usual office round clock-case, two small coils, one below and the other above the point of suspension, are used, having double magnets placed for each coil, through both of which the currents from the motor clock are passed.

This form of pendulum requires a more powerful battery to sustain its motion, and has less momentum than the long pendulums. Its construction is shown in the circular case, and in Fig. B.

5th. An arrangement to enable a pendulum vibrating half seconds to bea seconds is shown in Fig. C.

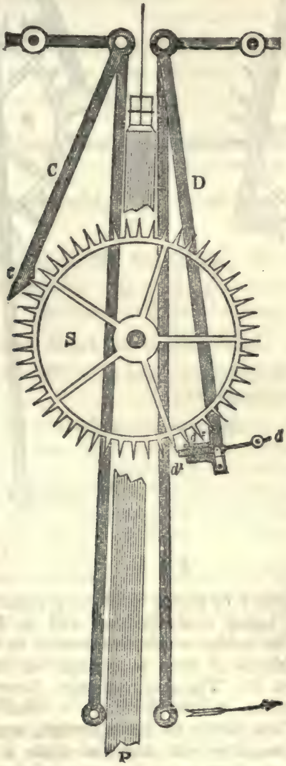


Fig. C.

6th. The wheel-work and hands are propelled by two gravity arms, one on either side of the 'scape wheel, which are alternately raised by the pendulum in its vibration.

The impulse pallets and stops are so adjusted that the wheel is impelled forward half a tooth, and locked upon the opposite arm until released by the return of the pendulum. The action of the propelment is shown in the large-sized movement in the square case, and in Fig. D.

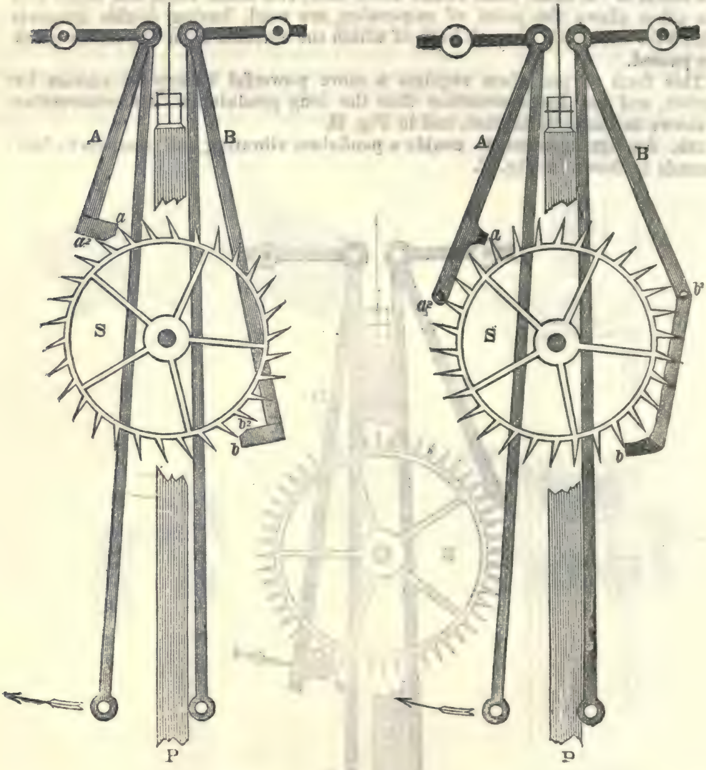


Fig. D.

In this system the standard or motor clock only requires winding, while the sympathetic pendulums, being controlled as well as driven by the electric currents transmitted by the motor clock, are caused to vibrate in unison, and so produce perfect coincidence of time on any number of clocks in connexion though miles distant from it. The electro-motive force being applied at the lower end of the pendulum, a long leverage is obtained requiring only a weak battery, which is less liable to derangement, maintains its constancy for a longer time, and requires less attention than a stronger one. Each subsidiary clock, being dependent upon its own pendulum for the time shown, is not affected by any trip or irregularity in the current, as the momentum acquired by the pendulum will carry forward the wheel-work for some time without any current. In systems where the electro-motive force is applied directly to move the wheel-work, a single miss of the current destroys the coincidence of time shown.

This electro-sympathetic system has for several years been in practical operation in the Royal Observatory and other public buildings in Edinburgh; the Royal Exchange, Manchester; the General Post Office, Glasgow; the Royal Dublin Society, Dublin; Leith Harbour and Docks, and Aberdeen. The clocks at the two ports last named are about two miles distant from the motor clock. The system is likewise about to be introduced into Birmingham.

1845. Ancient Sundial, for showing the time in any latitude, scale for setting the sun's declination, and equation table.
Elliott Brothers.

1845a. Ancient Sun Dial with correction for latitude and variation, dated 1579. *A. C. Baldwin.*

1848a. Sundial, date 1575. *A. C. Baldwin.*

1846. Sissons' Universal Ring Dial, for finding the sun's declination and place in the ecliptic, the latitude of any place, and the hour of the day. *Adam Dixon.*

1847. Two Ring-shaped Equatorial Sundials.
The Breslau Committee.

1848. Two Sundials, with calendars.
The Breslau Committee.

1849. Compass, with Sundial, of the year 1597, with various movable discs for adjusting the zodiacal circle, &c.
Berggewerkschaftskasse, Bochum, Westphalia.

1849a. Plaster Cast of a Sundial. The original is made of stone and is preserved at the Archæological Museum at Madrid.
Archæological Museum, Madrid.

This was found with a number of other objects at Yecla, in the province of Alicante, Spain. At the upper part there probably was formerly an iron limb to mark the hours, on the Roman system of dividing them in couples. In order to use it the dial was placed in the shade, facing the north. A small spherical concave mirror was placed at a short distance, which reflected the light of the sun upon the dial, and by that means projected the shadow of the needle marking the hours.

At the base of the instrument are inscriptions in Greek characters, but the language in which they are written appears to belong to one of the Semitic class. A description of this dial was written by Sr. Saavedra, and published in "Discurso leido en la Academia de la Historia de Madrid, porel Sr. Rada."

1849a. Poke or Pocket Dial. *John Ayling Blagdin.*

This was found about 25 years ago in a stream in Tillington parish, three miles from Petworth, whilst digging for the foundation of a bridge, and may be described as a ring of copper about 1½ inch in diameter, on the outer side of which are engraved letters indicating the names of the months with graduated divisions, and on the inner the hours of the day. In the inner slide there is a small hole which must be made to correspond to the month in which it is used. The circle is held up to the sun, the inner surface is then in shade and the sunbeam shining through the little orifice forming a point of light upon the hour marked on the inner side. In Knight's pictorial edition of Shakspere, "As you like it," p. 231, is a representation of a similar instrument.

The slide with the hole was wanting when it was brought to the exhibitor and was added by him, and the drawings of the whole were made by Mr. William Knight of Petworth.

1849b. Dial of a later date and more complicated construction. *John Ayling Blagdin.*

The same rules as above apply to this instrument, which was given to the exhibitor's father about 45 years ago by the Rev. Deival of Duncton.

1849c. Brass Instrument, apparently used as a **Sun Dial.** Maker, Sauter, Petersburg. *W. Clinton Baker.*

VI.—SIDEROSTATS.

1851. 'sGravesande's Heliostat, with his Equatorial Clock. *Conservatoire des Arts et Métiers, Paris.*

1851a. Siderostat, by Foucault. *Paris Observatory.*

1851b. Heliostat, by Gamberg. *Paris Observatory.*

1851c. Heliostat, by Silbermann. *M. J. Duboscq, Paris.*

1851d. Heliostat, by Foucault. *M. J. Duboscq, Paris.*

1850. Universal Heliostat, designed by Col. Campbell, and executed by Adam Hilger, 192, Tottenham Court Road. *Lieut.-Colonel Archibald C. Campbell.*

This instrument, after the polar axis has been set due north and south, and adjusted for latitude, will throw the light of a star or the sun in any required direction, and will keep it there by means of the clock; all the slow motions in altitude and azimuth can be manipulated by the observer without stopping the instrument. The connexions are placed ready to the observer's hand, wherever he may be.

A small telescope is also attached to the polar axis, so that it may act as a finder for any object, which, when seen in this telescope, will be reflected by the mirror to the required spot. The mirror is 1 foot by 8 inches, and is a perfect plane. This was also constructed by Mr. Hilger.

Dimensions.—Iron stands, 30 ins. diameter; height, 3 ft. 2 in. to centre of mirror. Mirror, 1 ft. by 8 in.

1851e. Photograph of a Siderostat, constructed by Messrs. Cooke and Sons of York, for the Royal Society. *J. Norman Lockyer, F.R.S.*

VII.—CELESTIAL PHOTOGRAPHY.

a. INSTRUMENTS.

1852. The Kew Photo-heliograph, or Telescope, employed at the Kew Observatory for taking photographs of the sun's disc. *Kew Committee of the Royal Society.*

It was constructed, in 1857, by Ross, on the design and under the superintendence of W. De La Rue, Esq., at the cost of the Royal Society; and erected at the Kew Observatory, where occasional sun pictures were taken by its means until 1860, when it was dismounted, and taken to Spain, for the purpose of photographing the solar eclipse of that year. This it accomplished most satisfactorily, and a full account of its work was published in the Philosophical Transactions.

On its return to England, Mr. De La Rue established it at Cranford, where during the year 1861, almost daily, solar photographs were taken with it.

In 1862 it was again removed to Kew, and there maintained in constant operation until 1872. In 1873 it was transferred to the Royal Observatory, Greenwich, where it is now superseded by an instrument of more recent construction.

The diameter of the object glass is $3\frac{4}{10}$ ins., and its focal length 50 ins. An Huygenian eyepiece is employed for magnifying the image, and the instantaneous exposure of the plate is effected by causing a sliding plate, containing an aperture variable at will, to be rapidly drawn across the focus by a strong spring, which is released from the top by cutting a thread.

1852a. De La Rue's Model of Tower for the proposed employment of Huygens' Long Focus Object-Glasses in Solar Photography. *Royal Society.*

1852a. Photo-Heliograph, constructed by Dallmeyer, and used for taking **Photographs of the Sun.** This consists of a telescopic camera equatorially mounted, and driven by clockwork. *The Astronomer Royal.*

The telescopic camera, total length about 8 feet, is made of brass tubing 5 inches in diameter, parallel for a length of 6 feet, when it opens out into a cone of about 2 feet in length, and sufficiently large at its extremity to receive the camera-screen, or sensitized plate, 6 inches square.

The object glass, of 4 inches aperture and 60 inches focus, corrected for coincidence of chemical and visual foci, occupies the other end of the tube furnished with the means of adjustment for focussing. The sun's image, produced by the object-glass at its focus, measures about half an inch in diameter, when it is enlarged, by a system of lenses termed a secondary magnifier (composed of two achromatised meniscus lenses turned concavity to concavity with an intervening space), to 4 inches on the camera screen. The secondary magnifier has all the necessary appliances for adjustment of focus. The difficulty to be surmounted in this arrangement is "optical distortion" in the enlarged image, which is, happily, almost entirely overcome.

Coincident in position with the small sun's image, formed by the object-glass, are perforations in the tube for the admission of sliders, containing apertures with cross-wires, glass reticules, &c. respectively; each capable of being placed concentric with the small image. At the same place also is the instantaneous shutter arrangement for effecting the exposures. This consists of a metal slide, perforated by a slit-opening. The shutter is actuated at one end by a spring, while at the other end a string, passing over a pulley and attached to a hook, can be made to hold the spring in a state of tension. This done, on the thread being cut or burnt, the spring is allowed to act, the shutter flashes across the image forming a cone of rays, exposes the sensitized plate, and the picture is produced. There are provisions for regulating the exposure by an alteration of the width of opening in the shutter, or by increasing or diminishing the tension of the spring.

The telescopic camera, attached to a bracket by means of two ring-clips or couplings, accurately turned, providing a motion in arc for the camera tube, read off by suitable scale and vernier, is bolted to the end of the declination axis.

Janssen's Apparatus. It is complete in itself and fits the same groove provided for the reception of the ordinary 6-inch collodion slide; the position planes of the sensitized plates also are identical in both, requiring no alteration of focus when using either description of slide. The apparatus is supported upon a flat piece of wood, or "carriage," the lower portion fits the camera groove, the upper part projects above the body of the camera and affords the means of attachment of a pinion wheel and arbor subsequently referred to. The carriage is perforated; the opening admits of a picture ½″ wide by 1″ high.

The sensitized plate is held in position by a circular cell of wood surrounded by a brass ring the periphery of which is racked with 300 teeth. It is free to revolve between three friction rollers, a pinion wheel originally cut with 12 teeth, of which 8 consecutive ones are removed, gears the racked edge of the cell, and when turned uniformly by a winch (situated near the centre of the telescope tube to prevent vibration) once per second during fifty seconds or for fifty revolutions, the plate-holding cell will have revolved *once* by an intermittent motion occupying *one-third* of a second and ceasing for *two-thirds.*

In front of the cell, *i.e.*, between the sensitive plate and the carriage opening, revolves a thin circular disc of brass, concentric with the plate but of smaller diameter. It is racked on its edge with 240 teeth, and is caused to revolve by a wheel having 60 teeth, which latter is mounted upon the pinion wheel arbor, and is therefore moved by the same winch that turns the plate-holding cell. The brass disc contains four apertures, equi-distant and otherwise corresponding in shape, set to the one opening in the carriage. (To regulate the exposure a mechanism is provided for simultaneously increasing or diminishing all four openings.)

The proportion of driver to follower being as 1:4 for one entire revolution of the winch the disc turns through one fourth of its circumference, so that when the winch is turned once in a second the cell containing the sensitized cell moves on for one third of that time, the brass disc or shutter moving also; after one third of motion the plate stops, but the shutter continues moving, and one of its four openings flashes across that portion of the plate, at that instant opposite the perforation in the carriage exposes and the photograph is taken. This is repeated for 49 times in succession. Thus 49 photographic images of a limited space are taken in 49 seconds of time.

Equatorial Mounting. This in outline resembles instruments constructed on the German plan, but is "universal," *i.e.*, admits of adjustment for any latitude up to 80°, either North or South of the Equator. A novel contrivance has been introduced for retaining clock gearing for great variations of latitude. Briefly the instrument combines all the most recent appliances for convenience of manipulation, and, though massive as regards construction, it may fairly be called portable. Eleven of these instruments have been sent to various parts of the world, without, it is believed, one single mishap.

1853b. One of the Photographic Apparatus used in the "Transit of Venus" Expedition.

The French Commission for Observing the Transit of Venus in 1874.

1853c. Photographic Revolver, used in observing the transit of Venus. *M. Janssen, Member of the Institute, Paris.*

1853d. Photographic Impressions, obtained with the revolver. *M. Janssen, Member of the Institute, Paris.*

1854. Short Focus Mirror, spherical, for telescopes, corrected by two lenses of homogenous media, for reflecting telescopes and astro-photography. With pamphlet.

Prof. Carl Wenzel Zenger, Prague.

1856. Apparatus for the production of **Photographs of the Sun,** after Dr. Oswald Lohse. *A. Fuess, Berlin.*

1857. Stand with **Equatorial Motion** about a vertical and horizontal axis for a photographic camera of 6″ aperture, used by the German expedition to Kerguelen's Island, for the observation of the transit of Venus, 1874. (Photograph.)

A. Repsold and Sons, Hamburg.

The point of intersection of the horizontal and vertical axis produced is at the same time the centre of movement of the equatorial system, which consists of an hour axis and a declination arc. This arc is suspended from a double arm fastened to one end of the horizontal axis and parallel to the telescope, it turns round this arm remaining concentric with the centre of motion. When clamped in the head of the hour axis, it turns with it, and compels the double arm, and at the same time the telescope, to move equatorially about the horizontal and vertical axes. By this arrangement the position of a thread in the focus of the object-glass can always be controlled by the level attached to the telescope. (See P. A. Hansen, "Beschreibung eines Fernrohrstatins," &c., in the Berichten der Kgl. sächsisch. Ges. d. Wiss. Mathem. Phys. A., 1 Jul. 1870.) To enable the telescope to follow the diurnal movement there is a screw moved by hand in time with the ticks of a clock.

1858. Small Spectrograph. Simple apparatus for taking the sun's spectrum, consisting of a camera (without objective), and a Browning's pocket spectroscope.

Prof. H. W. Vogel, Berlin.

The small spectrograph serves for studying the chemical effect of the different parts of the solar spectrum upon substances sensitive to light and for ascertaining the varying intensities of the various parts of the solar light at different places and times. The slit is wedge-shaped, in order to have more light at one side of the spectrum than at the other. The more intense the chemical effect of a colour, the further it reaches towards the dark end of the spectrum. The apparatus is held in the hand, and so directed upon the sun that the spectroscope may throw no shade. No heliostat is required. The exhibitor has been able to use the instrument on board ship, whilst sailing from Brindisi to Ceylon. (Pogg. Ann., Bd. 156, p. 321.) The exhibited apparatus has been made by *Schmidt* and *Haensch*, Berlin.

1859. Specimen Impression made with the small spectrograph. *Prof. H. W. Vogel, Berlin.*

b. PHOTOGRAPHS.

1860a. Photographs of the Arrangement for Obtaining Solar Photographs, by means of Huyghen's lens of 123 feet focal length. *J. Norman Lockyer, F.R.S.*

1861. Photographs of the least refrangible end of the spectrum, by iron and other processes. *Capt. Abney, R.E., F.R.S.*

1862. Daguerreotype of the **Total Eclipse of the Sun** of the 28th of July 1851, taken at the Observatory of Königsberg. *Dr. Schur, Strassburg.*

During the eclipse four photographs were taken. This one was formerly in the possession of Prof. A. C. Petersen, late Director of the Observatory in Altona, and after his death it became the property of his grandson, the exhibitor.

1863. Photographs of the **Sun,** taken with the Kew heliograph, and one of a scale put up for determining the amount of distortion produced by the instrument. *Kew Committee of the Royal Society.*

The Kew Observatory possesses a set of these negatives, extending from 1858 to 1872, and it is now employed in accurately determining from them the positions and areas of the spots observed during the 10 years 1862–1872, during which they were uninterruptedly obtained.

They are photographed on collodion fibrine, and developed by pyrogallic acid.

The sixth picture in the frame is one of a series of views taken, of a standard scale, suspended to one of the galleries of the Pagoda in the Kew Gardens, distant 1,500 yards, for the purpose of determining the optical distortion of the heliograph.

930a. Photo-engraving of a Group of Sun Spots. *W. De La Rue, D.C.L., F.R.S.*

Made from an original solar negative obtained with an equatorial reflector of 13 inches aperture, 10 feet focus, and a secondary magnifier attached to the eye end of the telescope. The negative being on a scale of 4 feet to the Sun's diameter.

1914d. Collection of Photographs, illustrating various expeditions for observing Total Eclipses of the Sun. *J. Norman Lockyer, F.R.S.*

1914e. Three enlarged Photographs of the Moon, by Mr. Rutherfurd, of New York. *J. Norman Lockyer, F.R.S.*

1917a. Photograph of the Sun, by Mr. Rutherfurd, taken with his triple combination. *J. Norman Lockyer, F.R.S.*

1917b. Enlarged Photographs of the Sun, taken by M. Janssen. *J. Norman Lockyer, F.R.S.*

1917c. Photograph of the Sun, taken by Professor Winlock, by a simple lens of 40 feet focal length.
J. Norman Lockyer, F.R.S.

1863a. Photographic Normal Spectrum of the Sun. Collection of enlarged comparison photographs, used in the research. *J. Norman Lockyer, F.R.S.*

1863b. Photograph of the Solar Spectrum, showing its absorption lines, by George Rutherfurd, of New York.
Robert James Mann, M.D.

The entire blue part of the spectrum is divided into sections, which are mounted above each other. When these are placed together in their proper continuation, the spectrum is nearly 8 feet long.

1863c. Photographic reproduction of the Solar Spectrum in its natural colours. First proofs obtained by M. E. Becquerel in 1848. (This proof, enclosed in a box, must be protected from the light.) *M. E. Becquerel.*

1864. Photographs of the less refrangible parts of the sun's spectrum, from line E downwards, and photographs of a larger spectrograph, which, being in use, could not be spared for this exhibition. *Prof. H. W. Vogel, Berlin.*

The accompanying photographs of the solar spectrum had been taken on silver chloride and bromide, which had been made sensitive to the less refrangible rays through addition of light-absorbing media.

1864a. Sun spots photographed at Wilna with Dallmeyer's Heliograph. *The Observatory, Wilna.*

These photographs are made with the Dallmeyer heliograph, constructed for the Observatory of Wilna, on the designs of De la Rue. Six of these belong to the period of maximum of sun spots in September 1870, 12 other represent the largest sun spots observed during the years 1871–1875. Similar photographs are made at Wilna every bright day, under the direction of Colonel Smysloff, for promoting the study of the surface of the sun.

1865. Photographs of different parts of the Sun's spectrum. *Dr. H. C. Vogel and Dr. Osw. Lohse, Potsdam.*

1866. Photographs of the Sun.
Dr. H. C. Vogel and Dr. Osw. Lohse, Potsdam.

1867. Photographs of Jupiter.
Dr. H. C. Vogel and Dr. Osw. Lohse, Potsdam.

1868. Drawing of the Spectrum of the Sun between Fraunhofer's lines H_1 and H_2, made from a photograph.
Dr. H. C. Vogel and Dr. Osw. Lohse, Potsdam.

1869. Specimens of Photographic Multiplication and **Reversion** of astronomical drawings of nebulæ and comets (Dr. Vogel's method).

Dr. H. C. Vogel and Dr. Osw. Lohse, Potsdam.

1870. Lunar and Solar Photographs.

Warren De La Rue, D.C.L., F.R.S.

The lunar photographs consist of:—

1st. A series of original lunar negatives obtained in the focus of an equatorial reflector of 10 feet focal length and 13 inches aperture. These should be examined with a lens in order to render the details visible. It will be noticed that the diameter of the lunar images varies in the several negatives, this arises from the moon being sometimes nearer to and sometimes more distant from the earth according to her position in her orbit.

2nd. A series of first enlargements 9-inches in diameter, collodion on glass transparent positives.

3rd. A series of paper positives 18 inches in diameter printed from negatives obtained by enlargement from the 9-inch positives.

4th. One paper positive 38 inches in diameter. The solar photograph is an original negative on a scale of 3 feet to the sun's diameter, obtained with the same reflector with the addition of a secondary magnifier placed at the eye end of the telescope.

1870a. Enlarged Solar Photographs, by Mr. Rutherfurd of New York. *J. Norman Lockyer, F.R.S.*

VIII.—CHRONOGRAPHS.

1871. Wheatstone's Magnetic Chronograph, for measuring very small intervals of time.

The Council of King's College, London.

1872. Groves's Chronograph, for astronomical calculations, for railway speed, and speed of machinery. *W. Groves.*

1873. Yvon Villarceau's Astronomical Chronograph.

Bréguet, Paris.

1874. Carrington's Astronomical Chronograph, made by Smith and Beck. *Dr. Stone.*

1875. Electro-magnetic Registering Apparatus.

M. Th. Edelmann, Physico-Mechanical Institute, Munich.

IX.—EDUCATIONAL.

1876. Sphere, moved by clockwork, of Just Burgh (1580).
Conservatoire des Arts et Métiers.

1877. Sphere, moved by clockwork, of Jean Reinhold (1588).
Conservatoire des Arts et Métiers.

1884. Planetarium or Orrery, designed by Ch. Huygens, constructed by J. Van Ceulen, set in motion by clockwork.
Prof. Dr. P. L. Rijke, Leyden.

1887. Model devised by the Rev. **James Bradley,** Savilian Professor of Astronomy, &c., and used by him for illustrating his discovery of **Aberration.** *R. B. Clifton.*

For a description of this model, see Phil. Mag., Dec. 1846, vol. 29, p. 429.

1879. Apparatus for demonstrating the **Retrogression** of the **Superior and Inferior Planets,** also the **Synodic Revolutions, the Transits of Venus and Mercury, &c.**
J. J. Oppel.

The long wire represents the line of vision, the small shield at one end the apparent position of the planet, the fixed ball at the other end the earth, and the movable ball the planet. The latter is fixed on the pivot of the smaller or larger turn-table, according as it is wished to demonstrate the retrogression of an inferior or superior planet. The twelve signs of the zodiac are hung up on the walls of the lecture room; the handle must be turned from left to right; the angular movement of the line of vision from left to right demonstrates the retrogression.

1880. Cosmographical Apparatus, to explain various natural phenomena, made by M. Robert, of Paris, and purchased for the South Kensington Museum in the Paris Exhibition of 1867.

1. The seasons.
2. The seasons.
3. Phases of the moon.
4. Eclipses.
5. Librations of the moon.
6. Real and apparent motion of the planets.
7. Fall of bodies.
8. Inequality of the seasons.
9. Precession of the equinoxes, physical.
10. Precession of the equinoxes, geometrical.
11. Precession of the equinoxes, mechanical.
12. Star to indicate a point in space.

1881. Nutoscope. Apparatus showing the laws of precession and nutation, and the conservation of the plane of rotation. With diagrams, constructed by the aid of the apparatus.
Prof. Carl Wenzel Zenger, Prague.

1882. Orrery, lighted with gas, for the demonstration of eclipses, and, by the aid of a "sablier," tracing the real orbit of the moon. *Ernest Recordon, Geneva.*

This apparatus shows:

1. By means of a jet of gas behind globes, representing the celestial bodies, a sufficient shadow is cast to give a clear idea of eclipses and the phases of the moon.
2. The orbits of Venus, the Earth, and Mars.
3. The difference in length of planetary years.
4. The diurnal rotation of the Earth.
5. The two classes of planets; the inferior represented by Venus, the superior by Mars.
6. The phases of the moon. Demonstration effected by means of a gas flame.
7. The real orbit of the moon. By means of a special contrivance, an epicycloidal line of fine sand is traced, which perfectly represents the lunar orbit.

1882b. Orrery. *The Earl of Cork, K.P.*

1884b. Azimuthal Planisphere.
Le Vicomte Duprat, Consul-General of Portugal.

1883. Selenographia, for showing all the effects of libration, rotation, and elongation on the surface of the moon.
John S. Marratt.

This instrument, the invention of Mr. John Russell, illustrates the various Lunar phenomena, the libration in latitude and polar obliquity, the libration in longitude, the mean state of libration, diurnal and monthly, the periodical and synodical revolutions, and how to determine the position of polar axis, &c.

1884a. Planisphere, with glass globe. *A. Herbst, Berlin.*

1885. Model of the Solar System, made by Professor Kaiser for his popular lessons on astronomy. The orbits of the planets from Mercury to Jupiter are represented in their relative dimensions.
H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

1885a. Cosmographic Clock, reproducing all the astronomical phases of our globe, in relation to the sun.
M. Mouret, Paris.

1888. Planetarium, with clockwork. *Ernst Schotte, Berlin.*

1889. Tellurium and Lunarium, with clockwork.
Ernst Schotte, Berlin.

1890. Tellurium and Lunarium.
F. Hornung, Langenbeutingen, Würtemberg.

1890a. Earth and Sun Instrument.

Horatio Allen, Homewood, South Orange, New Jersey, U.S.A.

This instrument presents clearly—

1st. The relations of the earth to the sun.

2nd. The relations of the surface of the earth in any parallel of latitude, in all positions of rotation, and at all places of the earth in its orbit, to lines of light and heat from the sun.

1891. Apparatus intended to elucidate the **Apparent Motions of Planets** seen from the earth.

H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

The apparent motions of a superior planet are depicted on the inner surface of a cylinder. This apparatus was made by Professor Kaiser for his popular lessons on astronomy.

1892. Apparatus for demonstrating the **Path of the Moon** round the Sun, as an epicycloid, without cusp or loop.

Dr. Charles Oppel, Frankfort-on-the-Maine.

When the handle is turned the moon will mark, by means of a pencil, to be inserted in the socket under it, its serpentine path on a sheet of paper laid underneath.

1892a. Solarium, a mechanism for Kinematic demonstration of the real orbits in the solar or the terrestrial system.

Royal Academy of Industry, Berlin, Director, Prof. T. Reuleaux.

In ascertaining the polar orbs (centroids) for the rotation of the earth about the sun, an ellipse is obtained in one focus of which the sun is situated. The polar orb of the earth is a circle, and the latter travels on the ellipse. The curves actually described by the earth are roulettes of this system. The mechanism is arranged for Kinematic adjustment, so that on the one hand the roulettes of the earth in the solar system, and on the other those of the sun in the terrestrial system, can be demonstrated.

1893. Model of the Paths of the Earth and of Venus, with movable balls on a stand, for demonstrating the position of the nodes and apses, inclination of the orbit, the period of Venus, culminations, &c. *J. J. Oppel.*

1894. Armillary Sphere of brass, to take to pieces, with horizon and azimuth, meridian, equator, ecliptic, tropics, and polar circles, movable sun, &c. *J. J. Oppel.*

This sphere demonstrates many of the definitions of spherical astronomy: zenith, altitude, and azimuth culmination, circumpolar stars, right ascension and declination, longitude and latitude, the seasons, hour-angles, sunrise and sunset according to time and place, length of the day, &c., &c.

1895. Apparatus for demonstrating (*a*) **Foucault's Pendulum Experiment,** and (*b*) the relation between the **Period of Revolution of the Pendulum** and **Geographical Latitude.** *J. J. Oppel.*

a. The apparatus, placed on a common centrifugal machine and turned slowly from right to left, shows the maintenance of the plane of oscillation of the pendulum with respect to the spectator and its apparent revolution relatively to the apparatus, a revolution which the ball of the pendulum (painted half black half red) does not itself accomplish. *b.* With a movable tangent cone the instrument demonstrates, by means of some large diagrams, that the fact and the reason of the apparent angular velocity of revolution of the pendulum being proportional to the sine of the geographical latitude.

1896. Apparatus for demonstrating the alteration of the date in journeys round the world, from west to east. Property of His Highness Prince Pless, Fürstenstein.

The Breslau Committee.

This instrument dates from the first quarter of the 18th century.

1897. Sidereal Atwood's Machine, with a ball, which represents either the moon or a planet. *Chr. Trunk, Eisenach.*

The peculiarity of the apparatus and its object are explained in the description which accompanies the model.

By its means a sphere, placed on a free vibration axis, is caused to oscillate with changeable velocity round a focus in an elliptic orbit, as the satellites round the planets, and the planets round the sun.

The apparatus shows the libration of the satellites and of the planets, causing the precession of the equinoxes.

1898. Ring Sphere. *Dr. H. Löckermann, Hamburg.*

This armillary sphere, of which a more detailed explanation accompanies the instrument, is to be used for instruction in mathematical geography. It is to serve for object lessons, and makes therefore no pretence to scientific accuracy. The instrument demonstrates the apparent motion of the sun and moon, and of the more important constellations (49 constellations with 359 stars of from first to fifth magnitude) at any given place and at any given time.

1899. Projection Apparatus. *J. and A. Molteni, Paris.*

1900. Descrivani's Orrery, by M. Pierret.

Conservatoire des Arts et Métiers, Paris.

1901. Wall Maps (11) for teaching Cosmography :—

1. The Ptolemaic system.
2. Tycho Brahé's system.
3. The Copernican system.
4. Comparative sizes of the sun and earth.
5. Comparative sizes of the planets (with map of Mars).
6. The seasons.
7. The phases of the moon.
8. Eclipses.
9. Parallax.
10. Comets.
11. Nebulæ. *Ernest Recordon, Geneva.*

1902. Three Astronomical Diagrams and Two Rules, with scales, for the solution of problems in spherical trigonometry.

Michael Elbe, Ellwangen.

The graphic representations drawn on the maps are called astronomical webs, and the rules contain scales. By the assistance of a diagram and a scale any problem in spherical trigonometry can be solved without calculation, a great advantage in navigation. It serves also on land for the determination of time and azimuth by means of one observation of a star.

In order to obtain the necessary accuracy in navigation, the drawing must be made as exact as possible by a machine, so that the accuracy of the solution, so far as it depends on the accuracy of the observing instrument, will be fully attained. Far greater precision will be arrived at by repetition, namely, by the easy reading of dozens of results which depend upon as many observations. Even the most extensive table for nautical calculation cannot effect this; besides which the inverse problem, often so difficult of solution, becomes a pastime by means of this apparatus.

1903. Specimen of Transparent Astronomical Chart, southern evening sky in winter, Central Europe.

Prof. J. J. Oppel, Frankfort-on-Maine.

1904. Specimens of Astronomical Diagrams, for teaching. White figures on black ground. *J. J. Oppel.*

In both instruments the circular plate (white on one side and black on the other) represents the plane of illumination, at *a* at the time of the equinoxes. The arrangement demonstrates as a necessary effect of a secular revolution from left to right of the plane of inclination of the earth's axis,—A the increase of the longitude of the stars; B the difference of the sidereal and tropical year; C the change of the pole star. The long wire at *a* can be fixed either in the direction of the pole (for A) or of the earth's axis (for C). The plane of the ecliptic is supposed horizontal; the appliance *a* must be turned from left to right slowly on its pivot.

1906. (1.) **Diagram for Nautical Astronomy,** engraved on stone; with a printed explanation. (2.) Diagram of Nautical Astronomy. Handbook of Practical Nautical Astronomy.

Prof. Prestel, Emden.

1907. Orrery, by Cole; explanatory of eclipses.

Royal Society.

1907a. Working Model, showing the annual and diurnal revolutions of the earth, thus illustrating the changes of seasons and the successions of day and night, designed by W. Adcock. Made by J. H. Adcock. *Thomas Murby.*

1908. Celestial Globe, 34 cm. in diameter.

Dietrich Reimer, Berlin (Reimer and Hoefer).

1909. Celestial Globe of 80 cm. diameter, with complete equipment. *Dietrich Reimer, Berlin (Reimer and Hoefer).*

X.—ASTRONOMICAL DRAWINGS.

Drawing made by William Temple of the **Nebula** of **Orion,** observed by him in the first months of the present year, by means of the great refractor of Amici.

The Royal Institute of "Studii Superiori," Florence.

1910. Unfinished **Chalk Drawings** of **Lunar Craters,** made with the reflector of 3 feet aperture, at Parsonstown, by Mr. Samuel Hunter, assistant in 1860 to 1864. *Earl of Rosse, F.R.S*

1910a. Chart of the Moon, drawn by hand by Tobias Mayer. *Prof. Dr. Winnecke, Strassburg.*

The highly interesting chart of the moon is the original drawing by Tobias Mayer, executed in the year 1750, which served for more than half a century as copy for all the maps of the moon used in nearly all the text-books. The autograph remarks on it, by the well-known Professor Lichtenberg, of Göttingen, show how and where the chart was preserved during the last century. It came into the possession of the exhibitor by a legacy of the late Privy Councillor Eisènlohr, of Carlsruhe.

1910b. Landscape of the Moon in relief, by Witte. *Prof. Dr. Winnecke, Strassburg,*

This view of the moon was executed by the celebrated Lady Frau Hofrath Witte, in Hanover, from her own observations. After her death it was presented to the exhibitor by her daughter Frau Staatsrath von Mädler.

1910c. Series of Astronomical Engravings, from the Observatory of Harvard College. *J. Norman Lockyer, F.R.S.*

MODELS, &c. OF ASTRONOMICAL INSTRUMENTS.

1911. Model of one of the three **Smaller Domes** for the new Imperial Observatory at Vienna, now in course of construction at Mr. Howard Grubb's Works, Rathmines, Dublin. Scale, 1 inch to a foot. *Howard Grubb, F.R.A.S., Dublin.*

This dome is supplied with Mr. Grubb's improved shutter, by means of which (being perfectly balanced in all positions) the shutters of dome roofs are as easily managed as those of drum roofs.

This is accomplished by a set of counterpoises, equal in the aggregate to the whole weight of the shutter, which are lowered one after another into the place prepared for them. When the shutter is half open all the weights are deposited, the shutter being then balanced in itself. The chains then lap round a roller prepared for them, and as the shutter opens still further the weights are again raised up one by one as the shutter gets heavier and heavier towards the back.

If desired, this form of roof can also be made to open beyond the zenith by placing a pair of doors at the base of the shutter "chase," which open automatically, and allow the shutter to roll back.

1912a. 11 Photographs of the buildings of the Observatory and its principal instruments. *The Pulkowa Observatory.*

1912b. 10 Photographs of several auxiliary instruments lately constructed by M. Herbst, at the mechanical workshop of the Observatory. *The Pulkowa Observatory.*

1912c. Photographs of Mr. Newall's Observatory. *J. Norman Lockyer, F.R.S.*

1914c. Two Photographs of the 25-inch Refractor constructed by Messrs. Cooke & Sons, of York, for Mr. Newall, of Gateshead-on-Tyne. *J. Norman Lockyer, F.R.S.*

1912d. Photograph of Galileo's Tribune at Florence.
J. Norman Lockyer, F.R.S.

1912e. Photographs of the Old Astronomical Circles at Delhi. *Mrs. Norman Lockyer.*

1912f. Photographs of the Lamp in the Cathedral at Pisa (interesting in connexion with Galileo's observations).
Mrs. Norman Lockyer.

1914. Photographs of Astronomical Universal Instrument. *F. W. Breithaupt and Son, Cassel.*

Astronomical universal instrument, portable. The movable circles have each two micrometers for reading the seconds; the vertical circle is 33 cm., and the horizontal 50 cm. in diameter. The broken telescope has an aperture of 67 mm. and a focal length of 80 cm., and is illuminated through the axis. The instrument revolves on the vertical axis; the horizontal axis is balanced on one plate only, and can be inverted on spring rollers. One level rests on the horizontal axis, a second is attached to the carrier of the micrometer, and a third can be inverted on the same. The second vertical axis which serves as a counterpoise is graduated. The instrument itself was made in the year 1873 for the Japanese Government at Yokohama.

Photograph of Astronomical Universal Instrument (portable). *F. W. Breithaupt and Son, Cassel.*

This instrument is provided with two movable circles, of 25 cm. diameter, each having two micrometers, with a side telescope of 27 mm. aperture and opposing vertical circle, the carrier of the micrometer being in the middle. By this arrangement the upper part of the instrument is kept low; it has also the advantage that, without alteration of position, the telescope, the two circles, as well as the numerating circle, can be observed. This instrument was constructed in 1875 for the Royal Mining Academy at Schemnitz.

Photograph of Universal Instrument (portable).
F. W. Breithaupt and Son, Cassel.

The circles are 20 cm. in diameter, the vernier reads to 10 seconds, the telescope of 40 mm. aperture is at the side, the azimuth circle is movable and the vertical circle attached to the telescope. All the verniers are covered with glass, and the alhidada of the vertical circle has a separate level. The instrument was made for the Imperial Observatory at Strasburg.

1914a. Photographs of Chinese Astronomical Instruments, enlarged by the Autotype Company from the original photographs by J. Thomson, F.R.G.S. *Autotype Company.*

No. 1. Ancient armillary sphere in the court of the observatory, Pekin. This instrument was made under the direction of Ko-show-king (during the Yuen or Mongol dynasty, about the close of the 13th century), one of the most renowned astronomers in Chinese history, and at the time chief of the astronomical board. The instrument is solid bronze, of huge dimensions and exquisite workmanship. A substantial metal horizon crossed at right angles by a double ring for an azimuth circle forms the outer framework. The upper surface of the horizon is divided into 12 equal parts marked with cyclical characters, the names of the 12 hours into which the Chinese divide the day and night. These are paired with eight characters of the denary cycle and four of the famous eight diagrams of the Book of Changes. The inside of the ring bears the names of the 12 states into which China was in ancient time divided. An equatorial circle is fixed inside the frame, within which a sphere turns on two pivots at the poles of the azimuth. This is made up of an equatorial circle and double ring ecliptic, an equinoctial circle, and double ring solstitial colure. The equator is divided into 28 unequal portions marked by the names of a like number of constellations of unknown antiquity. The ecliptic is divided into 24 equal parts. All these circles are divided into 365¼ degrees, corresponding to the days of the year, and each degree is divided into 100 parts, as the centesimal division prevailed for everything less than degrees, till the arrival of Father Verbiest in the 17th century.

No. 2. Armillary sphere on the terrace of the observatory at Pekin, made under the direction of Father Verbiest; *see* Thomson's "Illustrations of China "and its People."

No. 3. Celestial globe on the terrace of the observatory at Pekin; *see* Thomson's "Illustrations of China and its People."

1914b. Model of Hipparchus' Astrolabe, showing how that astronomer observed longitudes, and was enabled to determine the precesssion of the equinoxes. *J. Norman Lockyer, F.R.S.*

1914f. Photograph of the 9·62 inch Equatorial of the U.S. Naval Observatory, Washington, U.S.A.

Rear-Admiral C. H. Davis, U.S.N.

This instrument was made by Merz & Mähler and has been in use since 1845 in the observations of planets, comets, double stars, etc. The objective has been polished and refigured by Alvan Clark & Sons. The instrument differs in no important particular from those of the same makers at Berlin, Dorpat, etc. Its focal length is 14 feet 4·5 inches, it aperture is 9·62 English inches (9 French inches).

Photograph of the 26-inch Equatorial of the U.S. Naval Observatory, Washington, U.S.A.

Rear-Admiral C. H. Davis, U.S.N.

This instrument was constructed by Alvan Clark & Sons of Cambridge, U.S., and has a focal length of about 390 inches and an aperture of 26 inches, and is thus the largest refractor in the world. A full description of it may be found in the Washington Astronomical Observations for 1874, Appendix I. Its work has been, since 1873, the observation of the faint satellites of the outer planets, difficult double stars, and of nebulæ.

Photograph of the Transit Circle of the U.S. Naval Observatory, Washington, U.S.A.

Rear-Admiral C. H. Davis, U.S.N.

This instrument was mounted in 1866, and was made by Pistor & Martins of Berlin. Its focal length is 12 feet 0·1 inch and its aperture is 8.52 inches. A full description of it may be found in Washington Astronomical Observations for 1865, and also in the same publication for 1874, Appendix I.

Photograph of the Transit Instrument and Mural Circle of the U.S. Naval Observatory, Washington, U.S.A.

Rear-Admiral C. H. Davis, U.S.N.

These instruments have been in use since 1845. The Transit is by Ertel & Son, and has a focal length of 7 feet 0·4 inch, and an aperture of 5·33 (English) inches. The Mural Circle is by Troughton & Simms, the circle being 5 feet in diameter. This telescope has a focal length of 5 feet 3·8 inches and an aperture of 4.10 inches. It is upon the work of these two instruments that the positions given in the Washington Catalogue of 10,600 stars mainly depend.

Photograph of a Pastel Drawing of the Omega Nebula (G. C. 4403), made with the 26-inch Equatorial of the U.S. Naval Observatory, Washington, U.S.A.

Rear-Admiral C. H. Davis, U.S.N.

The drawing was made by Professor Holden and M. Trouvelot, and represents the appearance of this remarkable nebula in October 1875. It is fully described in the American Journal of Science for May 1875. There is a probability that changes are going on in the structure of the west end of this nebula, similar to those suspected in the nebula of Orion.

Photograph of a Pastel Drawing of the Ring Nebula in Lyra (G. C. 4447), made with the 26-inch Equatorial of the U.S. Naval Observatory, Washington, U.S.A.

Rear-Admiral C. H. Davis, U.S.N.

The drawing was made by Professor Holden, U.S.N. It is fully described in the Monthly Notices of the Royal Astronomical Society for November 1875. By close attention a small star can be detected within the ring which must have been much brighter when first seen by Von Hahn before 1800.

Photograph of a Pastel Drawing of the Planet Saturn, made with the 26-inch Equatorial of the U.S. Naval Observatory, Washington, U.S.A. *Rear-Admiral C. H. Davis, U.S.N.*

This drawing was made by M. Trouvelot, and is fully described in the Proceedings of the American Academy of Arts and Sciences for 1875.

Photograph of a Pastel Drawing of the Central part of the Nebula of Orion (G. C. 1179), made with the 26-inch Telescope of the U.S. Naval Observatory, Washington, U.S.A.

Rear-Admiral C. H. Davis, U.S.N.

This drawing was made from measures by Professor Holden, U.S.N., and M. Trouvelot. It is a preliminary chart of the Huyghenian region, which it is intended to complete. In the photograph the fainter portions of the nebula appear too faint, as compared with the drawing.

These photographs of instruments and drawings exhibited have been presented to the South Kensington Museum by Rear-Admiral C. H. Davis, U.S.N., on behalf of the United States Naval Observatory at Washington.

1915. Atlas Cœlestis Novus. Stellæ per mediam Europam solis oculis conspicuæ secundum veras lucis magnitudines e coelo ipso descriptæ ab Eduardo Heis D. Math. et Astron. Prof. P. O. in

Academia regia Monasteriensi. Coloniæ ad Rhenum 1872, impensis M. Du Mont Schauberg. Catalogus Stellarum.

I. Two volumes bound.

II. Thirteen plates for hanging on the wall.

Prof. E. Heis, Münster.

The Atlas Cœlestis Novus, the result of observation extending over 27 years, gives the appearance of the starry heaven as it is seen at the present day with the naked eye. It is more especially remarkable for containing, besides the stars of the 1st to 6th magnitude, those also between the 6th and 7th magnitude, which the author himself can easily distinguish. All the stars, without exception, are compared with one another in respect of magnitude by the naked eye, with the additional employment of other means of assistance; thus, among others, has been used the "method of sequences" of Sir John Herschel (*see* Results of Astronomical Observations at the Cape of Good Hope). The total number of stars observed by the author is 5,421, or 2,153 more than will be found in Argelander's Nova Uranometria. As no single star has been entered which has not been many times observed and compared, future observers will be able to judge whether in the course of centuries the sky has changed, whether any of the stars increase or diminish in brightness, whether some have disappeared, or others come into view.

The author has paid particular attention to drawing the milky-way with the greatest accuracy, and to show the brightness of the different parts in 5 degrees. For this purpose, the drawings made by Sir John Herschel of the milky-way in the southern sky were taken as models. The figures of the old constellations are copied from the classic figures on the ancient celestial globe in the Royal Museum at Naples. In the catalogue of the stars arranged according to the 57 constellations, their right ascensions and declinations, (Aug. 1855) are given; there are added also the numbers of Bayer and of Flamsteed (according to Miss Caroline Herschel); and also the numbers in the catalogue of the British Association for the Advancement of Science, and other catalogues.

1916. Chronometrograph, for the determination of true time. (Original drawing.) *Prof. Dr. Prestel, Emden.*

1917. Pictorial Representation of the Solar System, for the demonstration of the relative sizes of the sun and planets, also of the relative distances of the planets from the sun, and of the inclination of their orbits to the ecliptic. (Original drawing.)

Prof. Dr. Prestel, Emden.

1918. Chart of the whole Celestial Sphere in epicycloidal projection. *Dr. F. August, Berlin.*

This map gives a simultaneous view of the whole sidereal heaven. Each constellation preserves its proper form, for the representation is conformable, that is, proportional in the smallest parts. There is no want of conformity at any point, not even at the poles, so that even there the meridians cut each other at the correct angle. By this means the spherical form is always pictured to the eye; the arrangement of the map is easily imagined, by supposing an elastic envelope to be stretched about a celestial sphere, then cut open along a meridian and stretched on a frame. The course of the milky-way which follows one of the great circles of the heavens, and the parts comparatively free from stars which are at the poles of this great circle, are very well represented by means of this map. The map contains the stars from the 1st to the 6th magnitude.

The mathematical considerations which are necessary for accurately understanding the construction of the map will be found in the accompanying treatise: Ueber eine conforme *Abbildung der Erde nach der epicycloidischen Projection.* (Extract from the *Zeitschrift für Erdkunde,* Vol. IX., Berlin, 1874, published by Dietrich Reimer.

1919. Treatise on a **Conformable Representation** of the **Earth** by **Epicycloidal Projection.** (Extract from the Zeitschrift für Erdkunde, vol. IX., Berlin, 1874.)

Dr. F. August, Berlin.

XI.—MISCELLANEOUS.

Photographs of the Tribune of Galileo.

The Royal Institute of " Studii Superiori," Florence.

1. A view of the whole Tribune of Galileo. Galileo's statue was sculptured by the Professor Aristodemo Costoli. In the lunette at the end is represented Galileo while presenting his telescope to the Venetian Senate. The four greater instruments that can be observed in the angles of the middle part of the tribune are, at the right hand the odometer of the Accademia del Cimento, and the lens of Benedetto Bregans, at the left hand a Florentine astrolabe and the quadrant of Rinaldini. The other parts of the tribune are explained in the special photographs.

2. The left side of the further end of the tribune.—The lunette represents Galileo observing the oscillations of the lamp in the Cathedral of Pisa. The busts are those of Benedetto Castelli and Bonaventura Cavalieri, disciples of Galileo. The shelf contains the two telescopes of Galileo, and the broken object-glass.

3. The right side of the further end of the tribune.—The lunette represents Galileo blind, dictating to his disciples Torricelli and Viviani the geometrical demonstration of the law of the fall of heavy bodies. The busts are those of Evangelista Torricelli and Vincenzo Viviani. The shelf contains the natural magnet armed by Galileo, his compass of proportion, the first design conceived by him of the application of the pendulum to clocks, and the first finger of his hand.

4. Left side of the middle part of the tribune.—The lunette represents Galileo who, helped by his disciples, repeats the famous experiments on the descent of heavy bodies on an inclined plane. The shelves contain various ancient instruments, partly of the Accademia del Cimento.

5. Right side of the middle part of the tribune.—The lunette represent a séance of the Accademia del Cimento in which the experiment is being made to prove whether the cold of ice can be reflected by a mirror, like the heat of burning coals and light. The shelves contain ancient instruments, partly of the Accademia del Cimento.

6 and 7. Represent two shelves with ancient instruments, partly belonging to the Accademia del Cimento.

1924f. Old View of the Interior of Flamsteed House, Greenwich, with Flamsteed engaged in taking an astronomical observation. *Gardner Collection.*

Exterior View of Flamsteed House, showing position of astronomical instruments. *Gardner Collection.*

Ancient Sundial with Planetary Arrangements erected by Charles II. in the gardens of Whitehall Palace.
Gardner Collection.

1919a. Apparatus consisting of Thermopiles and Concave Mirrors employed in measuring the Moon's radiant heat. *Earl of Rosse, F.R.S.*

The reflecting mirrors were made alternately to receive the moon's image formed by the speculum of the three-feet telescope at Parsonstown, and the heat was concentrated by each in succession on the face of the corresponding thermopile, of which the diameter is about half an inch. The thermopiles are inserted in reverse positions in the circuit of a Thomson's Reflecting Galvanometer.

1920. Vinot's Sideroscope. *J. and A. Molteni, Paris.*

1921. Apparatus, constructed by Professor Kaiser, for determining the absolute value of personal errors in observations on the transit of stars.
H. G. Van de Sande Bakhuyzen, Director of the Observatory, Leyden.

The moment of the transit is registered by the action of a current. The construction of this instrument dates from 1858; the first observations were taken in 1859. (Dutch Records, Tome I., p. 193.)

1922. Observing Seat for Reflecting Telescopes, invented by the contributor. *E. B. Knobel.*

The observer sits as on horseback, and by simply raising himself off the seat, standing on the ground or on the movable footrests, as if in his stirrups, he can easily pull the seat up under him, and adjust it to the required height, without dismounting or moving from the eye-piece of the telescope. Releasing the ratchet wheel allows the seat to be lowered to any position.

1922b. Fittings for **Astronomical Telescopes.**
M. Lutz, Paris.

1855a. Perfect Diagonal Planes (2), $3\frac{5}{8}$ in. across the minor axis, for reflecting telescopes. *Adam Hilger.*

1855b. Right-Angle Prisms (9), for total reflection.
Adam Hilger.

1923. Cooke's Lamp for illuminating the micrometric spider webs of astronomical telescopes. *A. A. Pearson, Leeds.*

The lamp is inserted in the brass body of the instrument, where it is held by two projecting catches. The light, after passing through a condensing lens, is received by a rectangular prism placed at such an angle that the beam is totally reflected downwards into the window of the telescope, where its intensity and colour are modified by diaphragms. The lamp is suspended on a pivot, and also the framing and prism-box revolve from the bottom of the supporting pillar, so that it has a universal motion accommodating it to the position of the telescope. The weight of the end counterpoises the lamp, and the one at the side is the gravity poise. The top of the lamp is movable, and has attached internally a small tin chimney, which assists in promoting a draught and keeping it cool.

Perpetual Almanack.

The Royal Institute of "Studii Superiori," Florence.

1924. Calendarium perpetuum mobile.

Gust. Schubring, Erfurt.

1924c. Calendarium Perpetuum Mobile, eight Tables in glazed frame and in a stand. *Ch. A. Kesselmeyer, Manchester.*

A perpetual calendar, which gives the solution of any chronological problem during a period of from 10,000 years before to 100,000 years after Christ. The tables, which are still in course of construction, will contain the principles of a "Standard Calendar," as invented by the author, the object of which is to demonstrate the errors and inaccuracies both of the Julian and Gregorian calendars.

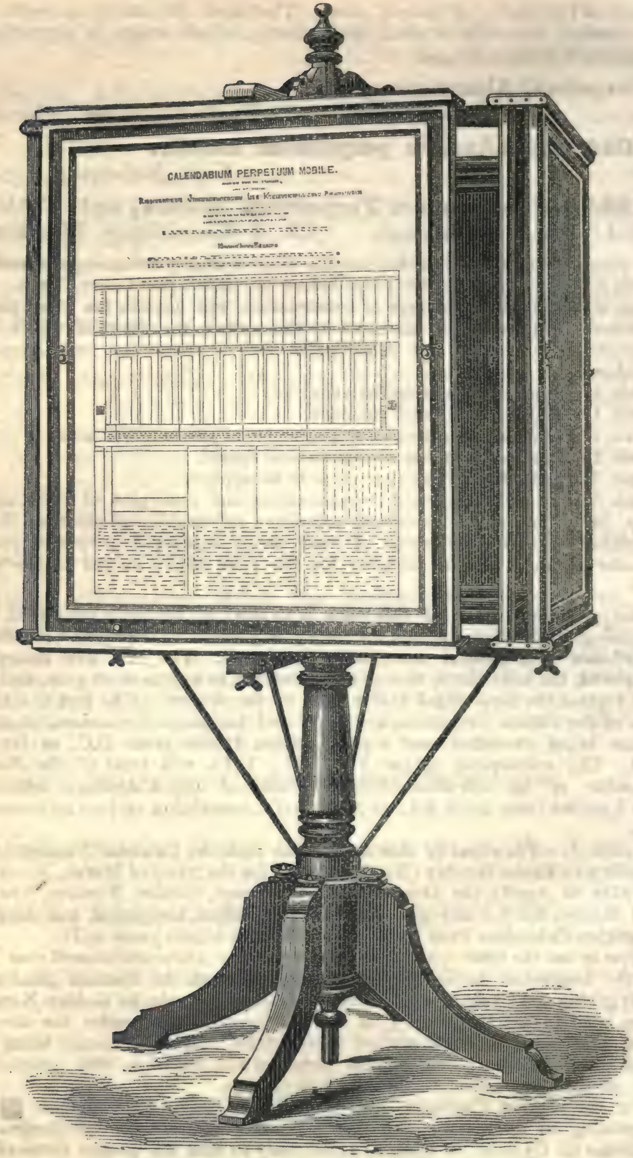
Tab. I. Adjustable universal calendar key.
Tab. II. Adjustable annual calendar.
Tab. III. Adjustable astronomical calendar of the northern zone.
Tab. IV. Table for finding the theoretical epacts.
Tab. V. Table for finding the epacts to be applied.
Tab. VI. to VIII. contain : explanations and examples of the Calend Perp. Mob.; adjustable universal calendar; adjustable indicator of dates; adjustable cylindrical indicator of week days; adjustable perpetual pocket calendar; annual pocket calendar for the year 1877 ; calend of the week days.

The principal object of this work is to solve all problems connected with chronological calculations, and ultimately to present an improved Calendar in accordance with present astronomical research. The first five tables are completed, the next three, now in the press, are to appear next year, and will then replace the three blank tables now in the frames. The first five tables treat of the Julian, Gregorian, and improved Gregorian Calendars, all calculations being extended over a period from 10,000 years B.C. to 100,000 A.D. The subsequent tables VI., VII., VIII. will treat of the *Normal Calendar of the Christian Era* (Reform of the Calendar), extending over a period from 2,000 B.C. to 3,000 A.D., containing various astronomical data.

TABLE I.—*The object of this table* is to find the Calendar Number corresponding to Easter Sunday (No. 1 standing for the 22nd of March, No. 35 for the 25th of April), the Dominical Letter, Epact, Golden Number, New and Full Moons, &c. for any given year of the Julian, Gregorian, and *improved* Gregorian Calendars from 10,000 years B.C. to 10,000 years A.D.

How to use the table.—For each century of the above-mentioned eras look for the Dominical Letter, the Golden Number, and the Number (Stellungszahl) giving the Cycle of 19 Epacts corresponding to the 19 Golden Numbers to be used during the century, in the catalogue situated under the movable frame, and place the same against these letters and figures, care being also taken to move the seven vertical strips of cardboard so that years either B.C. or A.D. are visible, as the case may require.

For the Julian Calendar always place the little black square ■ corresponding to the Golden Number 1 against Epact 8 or "Stellungszah." (Number of Cycle of 19 Epacts) 1, and only in case the proper dates of the mean astronomical New and Full Moons are required use the indicated


CALENDABIUM PERPETUUM MOBILE.

"Stellungszahl" or Number of Cycle of 19 Epacts. After the movable parts have been *properly* placed, the Number of the Calendar of the year, the New and Full Moons, &c. will be found on the same horizontal line, and the Dominical Letter, &c. in the same vertical column. The Solar Cycle can, however, only be ascertained by using the Julian Calendar.

TABLE II.—This table gives *the Calendar of a whole year* with all movable feasts, &c. as now generally in use on the Continent (especially Germany and Austria) by Protestants and Roman Catholics, and also contains a short sketch of the Calendar of the Greek Church, in which case the Julian Calendar or old style is to be used. The English edition would of course not be a mere translation of this calendar, as various data, such as the indication of the "terms," &c. (English and American) would have to be added, and feasts not used in England or America be suppressed. The top part contains a catalogue of Calendar Numbers for 2,000 years old style, and all Calendar Numbers new style since 1582 up to Anno 2,000.

How to use the table.—Look for the Calendar Number of the year either in the above-mentioned catalogue or, generally speaking, in Table No. I. for any year between 10,000 B.C. and 100,000 A.D., and then place the movable parts (left and right of the table) against the given Calendar Number, care also being taken to place the months of January and February so that the year may become a common or a leap year, as may be required.

TABLE III.—This table, besides giving the average position of the sun for Greenwich and Leipsic for the second half of the present century, the Solar and Lunar Eclipses for 2,000 years, and also the tide-tables for 400 places in Europe, gives the age and position, &c. of the mean astronomical moon for every day in the year corresponding to the "improved Epact," as devised by the author in the subsequent tables. It must be borne in mind that the mean astronomical New Moon precedes the New Moon of the Epact by one day, and the mean astronomical Full Moon falls one day later than the Full Moon of the Epact, which is always supposed to be the 14th day of the lunar month, New Moon being the 1st day.

How to use the table.—Look for the "improved Epact" of the year either in Table III. (for 2,000 years) or in Table I. by using the "Stellungszahl" (Number of Cycle of 19 Epacts) in Table V. (I^c Gregorian Calendar, I^D improved Gregorian Calendar, I^H Julian Calendar), and then place the movable parts against these Epacts, then the Lunar Calendar will be nearly correct. The dates may vary one day (rarely two days), this arising from differences of meridian, &c.

TABLES IV. and V.—These tables not only give the calculations of the Epacts as devised by Lilius and Clavius, but also give an improved method of the author's for finding them still more correctly. Supposing the length of the lunar month as used by Lilius to have been correct, his *method* of computing the Epact would still lead to a mistake of seven days in 100,000 years, always supposing that the length of the mean lunar month does not vary. Lilius having taken a mean lunar month slightly different in length from the one *now used* in chronological (not astronomical) research (*i.e.* the lunation by Tobias Meyer of 29 days 12 hours 44 minutes, $2^s \cdot 8283$), a mistake of two days would ensue in 100,000 years. Had he used Tobias Meyer's lunation his *method* would still have led him wrong by five days. The double error of the length of lunation and of method compensate each other up to two days error in 100,000 years. *Owing to the fact that the average length of the lunar month is gradually decreasing for a lengthened period of time,* and will ultimately lengthen again, to decrease later on (these periods being of very different lengths and in direct connexion with the position of the planets and the variable lengths of the minor axis of their orbits, which also act on the average length of the mean solar year of the earth), it can be proved that a *much greater mistake than two days will ensue for the now existing period of decrease of the average length of the lunar month.*

TABLE VI.—In this table the calculation according to Epacts will be advantageously replaced by a new calculation, in which lunar numbers will be used.

TABLES VII. and VIII.—In these tables greater simplicity and accuracy will be attained for our Calendar, as all necessary "corrections" will be adopted every secular year, as occasion may require, and not in accordance with a predetermined cycle as in the Gregorian Calendar. Easter can then either be maintained as a movable feast or become a fixed one, as it may be found desirable by modern astronomers and statesmen.

1924a. Calendar for Two Thousand Years.

M. Georges Sarasin, Geneva.

Lithographed sheet, framed and glazed, permitting the sight, by three openings, of portions of a second lithographed sheet which is capable of movement round a fixed centre. These lithographed sheets are divided into sectors of a circle radiating from a common centre, which is at the same time the centre of motion of the second. They are covered with figures and explanations. An inscription denotes briefly the method of use.

If, by the motion given to the central disc, the two figures which express the tens and units of a year, and the figure which constitutes—or the two figures which constitute—the hundreds (whether according to the Gregorian or Julian style), be brought into the same sector in such a way that the latter be to the left and the former to the right, the calendar of that year will be given on the lower portion of the sheet. The days of the week will correspond to the days of the month in the radial direction, and to the months in the circular direction, whichever of the two styles may have been chosen. There is no occasion either to give a new movement to the disc, or to take into consideration the dominical letter, except as serving to indicate the groups of years. Two of these *data* being given, the third may be found. When the three *data* are given, the years may be found, which, since the Christian era, have possessed them together.

The months of January and February are distinct according to whether it be a bissextile or ordinary year that is in question. In the former case, the tens and units figures, divisible by four, are separated by an empty space from the preceding in the table of years. A third designation of the two abovementioned months is also perfectly suitable to the two classes of years, if the date of the year immediately preceding be formed by the movement of the disc.

It may also be ascertained to what day of the ordinary week corresponds any date during the thirteen years of the Republican style which followed the year 1792, by taking for the hundreds portion the zero of the Julian style.

1924d. Reproduction of the Books on Astronomy, written by Dr. Alonso el Sabio, 13th century, from the original MS. at the Escorial.

Academia de Ciencias, Madrid.

"Libros del Saber de astronsmia del Rey Don Alonso el Sabio" 5 vol., gr. in fol., Madrid.

These volumes contain an extensive account of astronomical science in the 13th century, the plates reproduce among other details the constellations there known, and the astronomical instruments used at the time.

1924e. Reproduction in plaster of a fragment of the Zodiac (Aries). The original, in stone, is at the Archæological Museum at Madrid. *Archæological Museum, Madrid.*

This was found, with other objects of a very remarkable kind, at Yecla, in the province of Alicante (Spain). It has an inscription in old Greek characters relating to the subject.

1924f. Astronomical Symbol in the form of a Phœnix, probably of the beginning of the Christian Era, found at Yecla, Spain. *Archæological Museum, Madrid.*

The original in stone is at the Archæological Museum of Madrid. It has been illustrated and published in Sr. Rada y Delgado's study on his reception at the Academy of History of Madrid.

SECTION 12.—APPLIED MECHANICS.

SOUTH GALLERY.—GROUND FLOOR, ROOMS B. C.

I.—PROPERTIES OF MATERIALS.

217a. Machine for Testing the Strength and Ductility of Metals. *Sir Joseph Whitworth.*

The cylinder, pump, ram, and head are made of Whitworth's fluid compressed steel, so as to obtain the maximum of strength with the minimum of weight.

The machine is designed to test cylinders of one half a square inch in area, and it registers up to 100 tons per square inch.

217b. Cast Hoop of Whitworth's Fluid Compressed Steel. *Sir Joseph Whitworth.*

Strength as cast and compressed, 28 tons per square inch.

Strength when forged, 40 tons per square inch.

Ductility as cast and compressed, 18 per cent.

Ductility when forged, 30 per cent.

A hoop or ingot of the fluid metal while under pressure is shortened about ⅛ of its length.

A portion of the hoop exhibited has been turned to show the nature of the metal.

428b. Pieces of Steel Cylinders, torn by traction in experiments made to ascertain the influence of mode of treatment on the mechanical properties of steel.

Imperial Technical Society, St. Petersburg.

Annexed is a report on the experiments. Out of a block of unforged soft cast steel were cut, in identical positions parallel to the axis, 16 bars which were treated under heating or forging in eight different manners, two samples in each way. The samples were then turned to the shape of cylinders for tensile proof, and elastic and permanent elongations for each of them determined for a series of increasing tensile forces, density, hardness (by indentation), and other elements. Results indicated in annexed diagrams and tables.

420. Cement Testing Apparatus, for ascertaining the tearing strain of Portland and other cements, in sections of 1½ square inches. Originally designed for the Metropolitan Board of Works. **Press** for removing bricks from mould; and **Moulds** for making test bricks. *Patrick Adie.*

420a. Michele's Patent Cement Testing Machine.

De Michele, Rochester.

The block to be tested is placed in the jaws prepared to receive it; the handle is then turned, which raises the weighted lever by exerting a pull on its short end through the medium of the cement block. When the leverage is so increased as to exert a force too great for the cement to sustain, it breaks, and the lever falls, leaving the index-pointer at the spot to which it had been raised. The arc along which the pointer moves is graduated to show in number of pounds the tensile stress applied. A suitable arrangement, when the cement block breaks, prevents the lever from falling more than half an inch.

These machines are now in general use, nearly one hundred of them having been sent to different parts of the world. They are principally used by the leading royal and civil engineers in this country, and by a large number of contractors and cement manufacturers.

420b. Drawings of Machines and Apparatus for testing Materials.

Charles Jenny, Vienna.

Five sheets of drawings, representing :—

1. Machine for testing, by means of traction and pressure, the elasticity and rigidity of materials.

The machine of the Imperial Institute was constructed by C. Paff, Vienna.

2. Machine for testing materials. Werder's system constructed for testing elasticity and flexional rigidity. Executed by the Machine Factory Company, Kell & Co., Nuremberg.
3. Machine for testing materials. Werder's system. Constructed for testing the torsional elasticity and rigidity. Executed by the Machine Factory Company, Kless & Co., Nuremberg.
4. Machine and apparatus for ascertaining and determining the elasticity and rigidity of wire, leather straps, thin ropes, &c.

Executed in the former workshops of the Imperial and Royal Polytechnic Institute.

5. Optical apparatus for determining the modulus and the limits of elasticity by the application of the results obtained on tensile and compressive force, flexural elasticity, and rigidity.

The original apparatus of the Imperial Polytechnic Institute were constructed by G. Starke and Kammerer, mechanicians, Vienna.

426. Thurston's Testing Machine, invented by Professor Thurston, of Steven's Institute of Technology, Hoboken, U.S.A.

W. H. Bailey and Co., Manchester.

This machine is used for testing the limit of resistance, ductility, and homogeneousness of iron, brass, steel, and other materials of construction. By means of an ingenious but simple arrangement, a permanent diagram of the behaviour under varying conditions of the materials can readily be obtained.

423. Apparatus for determining the elasticity, tensile strength, and columnal strength of woods and timber.

Prof. Dr. Nördlinger, Hohenheim, Würtemberg.

423a. Apparatus used for experimenting on the Flexural and Torsional Rigidity of Solids, by Professor Everett, and described in the "Transactions of the Royal Society," 1866, p. 185.

Sir William Thomson.

424. Apparatus for determining the relative **Resistance to flexure,** and the **elasticity** of woods and timber.
Prof. Dr. Nördlinger, Hohenheim, Würtemburg.

427. Phroso-dynamic Apparatus for testing wires, by M. Alcun. *M. Digeon, Paris.*

1927. Cast-iron Test Bars. Specimens to illustrate the form and position of fractures when exposed to a breaking load.
W. J. Millar, C.E.

The bars were of 36″ span, 2″ deep, and 1″ broad.

The load was applied at centre of bars. Straight fractures occurred when bars broke at, or close to, centre of span ; but curved fractures when bars broke at points more or less removed from centre.

1927a. Metallometer for Testing Metals and Alloys by bending backwards and forwards a number of times through a certain angle. *Lewis Olrick.*

1957b. Drawings of Hydraulic Apparatus for the study of the extension, compression, and flexion of prismatic bars. Constructed by Professor Wischnegradski.
Mechanical Laboratory, Technological Institute, St. Petersburg.

This apparatus consists of a hydraulic cylinder, the piston of which bears a table supporting four iron columns, connected at the top by a strong cast-iron cross-head, that has at the centre a conical opening, and below a spherical recess within which pivots a hemispherical cast-iron piece, traversed by a powerful iron screw fixed by two nuts ; to this screw is attached the upper end of the bar subjected to the experiment of extension ; the lower end of the bar is fastened to the large lever placed at the base of the apparatus and which pivots round an axle fixed in an immovable bearing. This lever is connected with the upper lever, by means of two iron braces suspended to one end of this lever ; at the other end is hung a scale pan for the weights used in calculating the tension effected. The ratio of the two arms of the lower lever is 5, and that of the two arms of the upper lever is 20. So that each lever being perfectly balanced the tension of the bar is exactly 100 times that of the weight on the scale board. By means of the screw described above, and by inverting the intermediate iron pieces, it is possible, with this apparatus, to experimentalise upon bars of any length up to 10 feet English.

No. 1 represents the apparatus arranged for experiments of extension.

No. 2 represents the apparatus arranged for experiments of flexion.

No. 3 represents the apparatus arranged for experiments of the compression of long bars.

The deformations in the bars are measured with a cathetometer constructed by Mr. Brauer, and the original section of the bar with an apparatus by the same engineer. The readings are given to the $\frac{1}{200}$ of a millimeter.

II.—SPECIAL COLLECTIONS.

COLLECTION OF THE ORIGINAL MODELS OF STEAM ENGINES AND OTHER MACHINES OF JAMES WATT. PRESENTED TO THE SOUTH KENSINGTON MUSEUM BY MESSRS. J. WATT AND CO.

1928a. Imperfect Model of method of converting reciprocating into rotatory motion by means of teeth or pins fixed to the connecting rod, which gear with the teeth in a wheel, and cause it to revolve. Some point of the connecting rod is guided by a pin, moving in a groove, so as to keep the teeth or pins always engaged in the teeth of the wheel.

This method of converting reciprocating into rotatory motion is included in Specification of Patent granted to James Watt, dated October 25th, 1781.

1928b. Two Fragments of a Model, consisting of wood rods with oval holes geared internally, and apparently belonging to one of the models selected from the Soho Works by the late Sir Francis Smith, as an illustration of one of the methods of converting reciprocating into circular motion.

1928c. Model of Grinding Mill, 6 pairs of stones in two sets of 3 pairs each, each set driven by a spur wheel with bevil gearing. The two fly wheels are connected and driven by pin and connecting rod.

1928d. Model of Grinding Mill, with six pairs of stones, in two sets of three pairs each. Each set driven from one spur wheel by bevelled gearing.

The two fly wheels are connected, and driven by one connecting rod, fitted with two sets of stepped sun and planet wheels.

1928e. Model of Rolling and Slitting Mill, driven by two connecting rods, on one beam, and fitted with sun and planet stepped gearing.

This improvement, consisting of new methods of applying the power of steam engines to drive mills for rolling and slitting iron and other metals, is included in Specification of Patent, granted to James Watt of Birmingham, and dated April 28th, 1784.

1928f. Model of Rolling Mill, driven by a connecting rod, fitted with stepped sun and planet motion, and with two fly wheels.

1928g. Model of two Tilt Hammers, at right angles to each other, one hammer actuated at the tail by cams, the other by lifting cams, driven by one connecting rod fitted with stepped sun and planet motion.

NOTE.—Part of the above model is missing, and the helve of one tilt hammer is broken.

1928h. Model of Wheel (probably for grinding). With sliding axle.

1928i. Fragment of Model (probably a pump bucket).

1928k. Models on a Stand, of four trussed beams, probably used experimentally for testing the strength of different methods of trussing.

1928l. Fragment of a Model of a Frame for a Machine.

1928m. Fragment of a Frame.

1928n. Model of a Horse Mill, with roller and trough, apparently designed for crushing material.

1928o. Model of a Train of Wheels.

1928p. Model of Beam and two connecting Rods with universal motion at their upper ends, and connected to transverse hinged links at their lower ends.

1928q. Model of Beam Pumping Engine, single acting and condensing, worked by tappet valve motion.

1928r. Model of double acting Beam Condensing Engine, conical valves worked by eccentric.

1928r. Model of inverted Cylinder direct-acting Pumping Engine, with tappet valve motion.

1928s. Sectional Model of Beam Engine, worked by eccentric and hollow valve.

1928t. Sectional Model of Engine, with shifting eccentric for altering valve.

1928u. Model of a Pair of Tilt Hammers, alongside each other. Two beams and connecting rods, with cranked pins at an angle to each other, and one of the wheels provided with a balance weight.

(NOTE.—Part of the above model missing.)

1928v. Fragment of a Model with part of Sun and planet motion.

1928w. Fragment of a Model with Sun and planet motion and weighted disc.

1928x. Fragment, an arch head.

1928y. Model of a Water Wheel.

1928z. Measuring Apparatus, with Micrometer Screw, for taking end measures.

1928aa. Model of Garnet's Patent Friction Rollers.

1928bb. Model used for Testing Pressure due to Vacuum.

1928cc. Model of Valve with Universal Joint.

1928dd. Brass Model in two Pieces.

1928ee. Model used in experiments on Governor.

1928ff. Experimental Model.

1928gg. Experimental Model.

1928hh. Experimental Model.

1928ii. Original Model of Cylinder with separate Condenser.

1828jj. Model of Surface Condenser.

III.—PRIME MOVERS.

a. STATIONARY ENGINES.

2019d. Papin's Steam Cylinder.

Royal Museum, Cassel (Director, Dr. Pinder).

This cast-iron cylinder was to have formed part of a large pumping engine, which, however, was never completed. The object was to supply a canal at the level of Hofgeismar with water, whereby the Landgraf Charles hoped to draw the traffic of the Weser to Cassel. An explosion which took place in Papin's laboratory when the Landgraf was contemplating a visit, led to the bold investigator withdrawing from the influence of his enemies. He came to England (1707), but did not succeed with his plans, and died in poverty. Papin's sketch of his contemplated pumping engine is exhibited with the cylinder. It was a peculiar combination of the Savery engine and the piston engine recommended by Papin for other purposes. In the closed boiler A (with safety-valve of Papin's design), steam was generated, which (on opening the cock C) could pass through pipe B to cylinder D. Here it pressed down the close fitting piston or float E which rested on water that had been supplied through the funnel I from a reservoir. The water was thus forced into the chamber F; its return was prevented by a valve at H; and the steam-cock C being now shut and the condensed steam allowed to escape from the upper part of D, water from the reservoir was admitted anew, and the process repeated. The water raised into F could be further directed through the tube G. Papin proposed to add to the effect by introducing red hot irons through the opening in the cover of the cylinder D. Of the two cylinders it is probably D that is exhibited.

The cylinder went to the Government foundry at Cassel, and was used there for many years as a receptacle for the chips under a machine for boring pump barrels. When, in the year 1836, this establishment, at that time under the direction of the superintendent of mining works, Henschel, was burnt to the ground, the cylinder was saved, and bought by the manufacturing firm of Henschel and Son, founded by them after the fire. Here it was at first used for the same purposes as before; but afterwards, about the year 1837, being provided with the label "Papin's steam cylinder," it was placed opposite the main entrance to the factory. Behind it lay the stock of old iron, moulds, &c., which was destined to be melted down. For anyone who may have seen it, as it stood there for many a long year, the following passage in the work of the latest biographers of Papin must, to a certain extent, appear very strange. Speaking of the cylinder, they say:—

"Alors on le relégué dans un coin obscur, sur un tas de ferailles, destinées au fourneau. C'est là que, dans le mois d'Avril de l'année 1863, l'un de nous, voyageant en Allemagne, eut le bonheur de le retrouver."

How could the traveller, without having read the label, or received any information on the subject, have been able to perceive the original purpose of the cylinder, resting as it was in the midst of pieces of old iron? Nor was there ever the slightest intention of treating this valuable relic as an object fit only to be melted down. On the contrary, as the prosperity of the factory increased rapidly since 1866, and the arrival of so many new workmen seemed to threaten the danger that through their ignorance of the value of the cylinder it might suffer harm, the present proprietor, the Privy-Councillor of Commerce, Henschel, grandson of the late Superintendent of Mines, caused it to be removed to a more secure corner. Now the biographers of Papin continue:—

"A son retour il (l'un de nous) s'empressa d'instruire le Général Morin, directeur de notre Conservatoire des Arts et Métiers, de la destruction imminente de ce monument des travaux de Papin. Le général se hâta d'écrire au successeur de M. Henschel [his grandson] pour lui en proposer l'acquisition ou l'échange. Une négociation suivit; malheureusement les prétensions exagérées du détenteur et empêchèrent d'aboutir. L'œuvre de notre compatriote existe-t-elle encore? Hélas! nous ne saurions le dire."

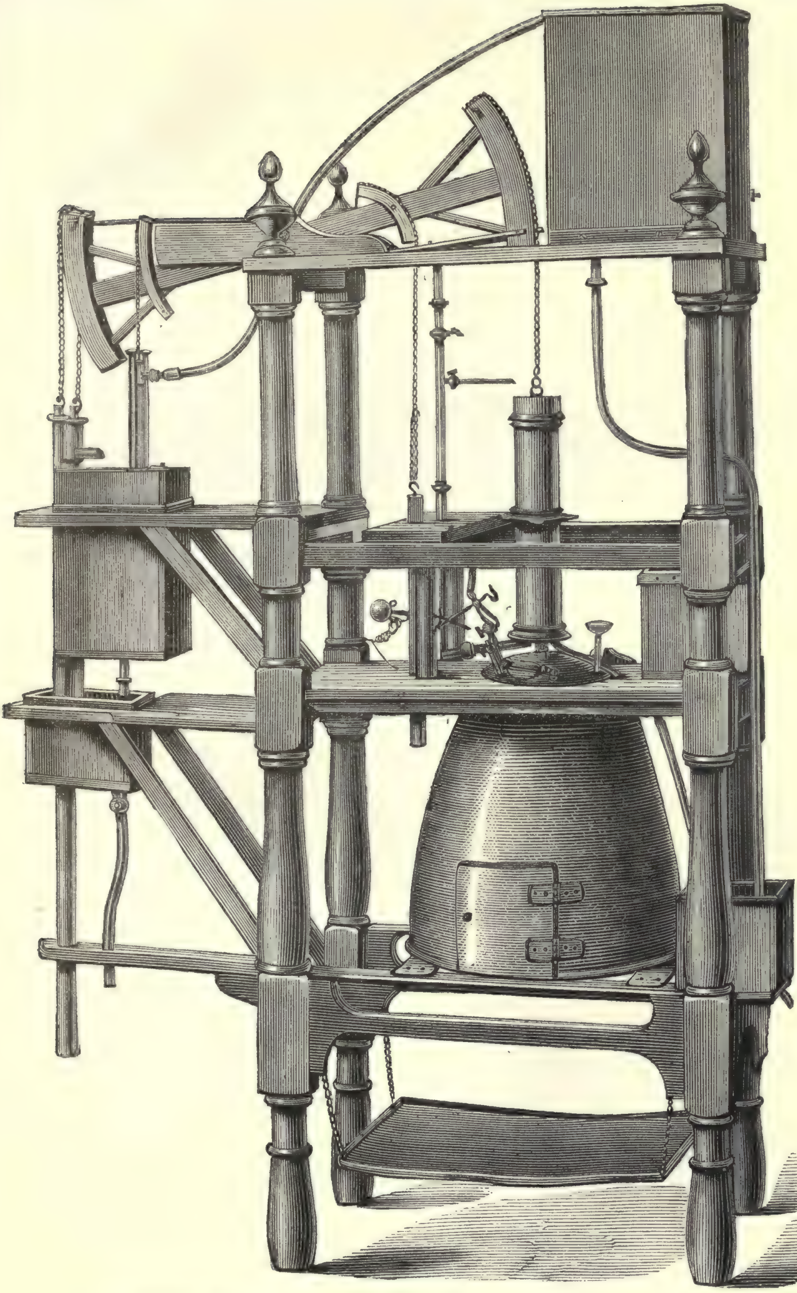
This question, thrown out by *de la Saussaye,* who has in the meantime died, can be answered by the cylinder itself. The circumstance that it is in the possession of the museum at Cassel will show in their proper light the "prétensions exagérées." Herr Henschel did not wish to sell the cylinder, he wished to keep it for his native town. In fact, in 1869, he presented it to the Cassel Museum, to which institution the gift is especially valuable, inasmuch as it shows to what degree, even at the beginning of the last century, the art of iron foundry had reached in Hesse.

1943. Original Model of Newcomen's Steam Engine.
The Council of King's College, London.

1942a. Drawing of the Newcomen Engine, in the possession of the University of Glasgow. *Thomas Ledstone.*

1944. Model of Captain Savery's Steam Engine. This form is a modification by Dr. Desaguliers, constructed about 1717. The first complete engine of this kind was made for the Czar of Russia (Peter the Great), for his garden at Petersburg. 1717 or 1718. *The Council of King's College, London.*

[To face page 450.]



Original Model of Newcomen's Engine, described under No. 1943.

Newcomen Engine, repaired by Watt, the property of Glasgow University. *Sir William Thomson.*

Engraving by T. Barney (1719) of the steam engine near Dudley Castle, invented by Captain Savery and Newcomen, erected by the latter 1712. *Thos. Dow, Exeter.*

Engraving of Newcomen and Savery's Engine.
Bennet Woodcroft, F.R.S.

1932. Sectional Model of a **Cabinet Steam Engine.**
H.M. Commissioners of Patents.

This is a sectional model of a steam engine in the Patent Office Museum, and was made for the purpose of showing the following improvements in the steam engine made by James Watt. (The engine in the Patent Office Museum was the property of James Watt.) Improvements above referred to:—

a. Making the engine double acting.
b. Keeping the cylinder heated while the engine is at work by surrounding it with steam.
c. Using a separate condenser and air pump.
d. Parallel motion.
e. The governor.
f. The D slide valve.

1828kk. Model of a Steam Engine, made by James Watt, which since 1799 has been used to pump water from the mines of Almaden. This engine was the second set up in Spain. The first steam engine employed in Spain was placed at the arsenal of Ferrol, on Newcomen's design, improved by Watt and Boulton. *Royal School of Mines, Madrid.*

1828ll. Plan of the Steam Engine used to pump water from the mines at Almaden, drawn in 1830, by Vicento Romoro.
Royal School of Mines, Madrid.

1828mm. Plan, Outline, and Sections of the Boilers of the Steam Engines used in the quicksilver mines at Almaden, drawn by Vicento Romoro, in 1830.
Royal School of Mines, Madrid.

1930. Original **Model** of **Stirling's Air-engine.** Made by the inventor. *University of Edinburgh.*

1940. Working Model of **Stirling's Air Engine,** presented by the inventor, the Rev. Robert Stirling of Galston, to the Natural Philosophy Class of Glasgow University, and used constantly for lecture illustrations. *Sir William Thomson.*

1960. Working Model of Atmospheric Engine, with sun and planet motion. *Glasgow Mechanics' Institution.*

1935. Wood Model of **Disc Engine.** (Taylor and Davies' Patent, 1836.) *Bennet Woodcroft, F.R.S.*

1939. Models (2) of **Rotary Engines.**
Bennet Woodcroft, F.R.S.

1931. Rotary Steam Engine. Designed and made by the Rev. Patrick Bell. *H.M. Commissioners of Patents.*

2136. Stationary Direct-acting Steam Engine (model).
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

The cylinder and valve chest are opened so as to show the various parts. The eccentric is adjustable with reference to throw and lead; accordingly the valve rod and valve are changeable.

This model shows the general arrangement and essential details of a stationary direct-acting engine, and is arranged specially to demonstrate the relative motions and positions of the piston and the slide valve, and the mechanisms connected with them.

It shows :—

1. The dead points of the machine;
2. The necessary relative positions of eccentric and crank;
3. The way in which a steam engine is compelled to move in one direction.
4. The lead of the valve and the eccentric, and their influence upon the steam admission;
5. The lap of the valve and its connexion with the angular advance of the eccentric and the expansion of the steam;
6. The irregularities in steam distribution and in the transmission of motion to the fly-wheel, caused by the obliquity of the connecting-rod; and
7. The effects upon the steam distribution of an eccentric rod of wrong length or an eccentric wrongly adjusted.

2137. Model of a **Direct-acting Cornish Pumping Engine,** with cataract.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

This (also with open cylinder) has a cataract of simple construction, and a systematically arranged valve motion.

The model serves, in the first place, to illustrate the general nature of click-trains used as valve gear, and their application by means of a plug rod and tappets worked from a beam. It also shows in particular the mode of employing a condenser in a single-acting engine, where three valves (admission, exhaust, and equilibrium) are necessary, with their three separate weigh shafts and wipers, clicks, weights, and levers. The commencement of the expansion is shown very distinctly by the closing of the inlet valve. The pause at the end of the "indoor" stroke is effected by means of the cataract, which is filled with petroleum; the action of this mechanism can be very distinctly observed. With a slow motion of the cataract, it can also be easily noticed that the exhaust valve opens a little sooner than the steam valve, in order that a sufficient vacuum may exist on one side of the piston before the steam is admitted on the other.

The condenser itself is omitted in order to simplify the model and to make the complicated valve gear somewhat more easy to understand. A lever for the injection valve only is shown, to show that this valve must be opened before the engine can start.

For simplification, the cataract which determines the short pause at the end of the " outdoor " stroke is also omitted.

2141. Model of a Horizontal Steam Engine, with reversing gear (Gooch's link).

Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

This model is intended to illustrate the action of the link motion generally, and especially that with adjustable block.

The link can be worked in two ways. Either its centre can be suspended and an eccentric rod connected with each of its ends, or its centre can be fixed, and one eccentric rod only used; an arrangement often employed, for example, in hoisting engines.

It shows very distinctly that with two eccentric rods with their eccentrics placed 180° apart, the centre of the link moves to and fro, and that this error can be almost entirely prevented by giving the eccentric a little advance.

2143. Horizontal Steam Engine, with reversing gear (Stephenson's link).

Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

.With the above model this shows the two chief systems of link reversing gear, their differences, and their comparative advantages and defects. The link has here a different form to that employed in the last case, partly simply for the sake of variety, and partly to show the influence of the position of the point of suspension upon the motions of the link.

Models of mechanisms :—

The eccentric is here also adjustable for variations of lead.

1941. Model of **Dawes' Compound Stationary Engine.**

In this the low-pressure cylinder is horizontal, and the high pressure is arranged over it, at an angle of 30° to the centre line of low pressure. The connecting rods couple to a single crank; the air pumps and condensers are driven off the low pressure crosshead, and being two in number are arranged on each side of connecting rods. *Henry P. Holt, C.E.*

1937. Model of a **Caloric Engine** (unfinished).

Bennet Woodcroft, F.R.S.

1933. Drawing of " Head's Patent Prime-mover."

Jeremiah Head, M.Inst.C.E.

Being an inverted, direct-acting, non-condensing steam-engine, with steam-jacketed cylinder and covers, cylindrical slide valves, and variable expansion gear, controlled by a liquid-cataract parabolic governor, and balanced throughout for running at a high speed.

1944a. Working Model of latest improved horizontal high-pressure coupled winding engines, with winding drum as supplied for coal, copper, iron, salt, and other mines.

Messrs. Robert Daglish and Co.

2211. Steam Engine. Tangye's (Willan's Patent) four-inch three cylinder steam engine with horizontal multitubular boiler, feed pump for same, and all fittings complete.

Tangye Brothers and Holman.

This engine is of the simplest construction possible; it is self-contained, has neither eccentrics, separate slide valves, nor piston rod guides, and can be driven at a very high rate of speed without the slightest noise.

2212. Steam Engine. 6-horse power expansion portable steam engine, fitted with Head and Schemioth's patent straw burning apparatus and patent automatic governor expansion gear.

Ransomes, Sims, and Head.

By means of this patent invention all kinds of vegetable substances can now be used as fuel in a portable steam engine, such as straw, reeds, dry grass, cotton and maize stalks, brushwood, &c., and by removing the patent apparatus the engine can also be fired with wood or coal in the ordinary manner.

This engine is also fitted with a separate expansion slide valve, and Brown's patent automatic governor expansion gear, which consists of a link motion attached direct to the expansion valve, and under the control of the governor, by means of which the amount of steam admitted into the cylinder is varied instantaneously in exact proportion to the work to be performed by the engine; an arrangement of the utmost importance in all cases where the load on the engine is suddenly increased or diminished, or where exact regularity of motion in the machine which is being driven is essential to success. The engine has also a simple and efficient arrangement for heating the feed water by means of the exhaust steam, and is provided with two safety valves, steam pressure guage, and all the most modern and complete fittings and accessories.

1954. Drawing, on a scale of ½-inch to 1 foot, of a patent horizontal high-pressure condensing steam engine; designed and made by the Reading Iron Works Co., Limited, Reading.

South Kensington Museum.

This drawing shows a side elevation of the engine and a through plan.

It represents an engine of 25 horse-power nominal; having variable expansion gear, fly wheel, governor, feed pump, and condenser.

A similar engine was employed to drive a part of the British machinery in motion at the Vienna Universal Exhibition for 1873.

1955. Photographs, two, of a compound horizontal-cylinder condensing steam engine. Constructed by the donors in 1873. 120 indicated horse-power. W. and J. Galloway and Sons, Engineers, Knott Mill Iron Works, Manchester.

South Kensington Museum.

One photographic view is of the cylinder end of the engine; the other shows the fly-wheel, crank shaft, and governor motion, &c.

The high-pressure cylinder is 14 inches in diameter. The low pressure cylinder is 24 inches in diameter. The stroke of the piston is 2 feet 6 inches.

This engine was employed in driving a portion of the British machinery in motion at the Vienna Universal Exhibition of 1873.

1956. Photograph of Brotherhood's patent three-cylinder high-pressure steam engine, arranged as a stationary engine.

The engine was designed and patented by Mr. P. Brotherhood in 1872–73. Brotherhood and Hardingham, Engineers, London.
South Kensington Museum.

1956a. Model of **Brotherhood's** patent **Three-cylinder Hydraulic engine** arranged for turning a capstan, the pressure being supplied to the engine by a Brotherhood's patent three-cylinder pump. *Hydraulic Engineering Company, Limited.*

1967. Model of horizontal engine (novel girder pattern), with portion of cylinder removable to show the action of a variable automatic expansion valve gear (Rider's patent), controlled directly by the governor. The expansion valve works on the back of the lower valve by a separate eccentric in the ordinary manner, but owing to its triangular shape, and the form of the parts, the point of cut-off changes according to the angular motion of the valve round its spindle. This angular rotation is produced by the rise and fall of the governors through rack and quadrant. Any acceleration in speed thus affects the rise and fall of the governor balls, and accelerates or delays the time of steam admission.
Hayward Tyler & Co.

1981. Model of Robey and Co's. semi-portable mining and winding engine. Richardson's patent. Robey and Co., Lincoln.
South Kensington Museum.

1957. Working Model of a stationary steam engine.
Royal Trade School, Halle (Director, Dr. Kohlmann).

2178ggl. Drawing of a Portable Engine, 1828.
Maudslay, Sons, and Field.

1945. Atmospheric Gas Engine. Otto Langen and Crossley's joint patents. Actuated by the vacuum resulting from the explosion of common coal gas and air. *Crossley Brothers.*

In this engine, which works by the vacuum resulting from the explosion of common coal gas and air, the piston is not, as is usual, connected with the shaft on both up and down stroke, but on down stroke only. It is thus at liberty to fly up freely from the force of the explosion, which takes place at the bottom only, and by driving the piston before it empties the cylinder of air through its open upper end. The return of the air on the down stroke yields the driving power, and turns the shaft by means of a friction clutch, to which the piston is geared by the rack. The vacuum beneath the piston in equal to about 11 lbs. per square inch for the greater part of the down stroke. The governor does not act, as is usual, by increasing or decreasing the power of each stroke, but by varying the number of strokes, each being of the same power. This is done without materially changing the speed of the shaft. Three or four explosions per minute are generally sufficient to turn the engine itself, and as a maximum of 30 to 35 may be made, there is a balance of, say, from 26 to 32 strokes or explosions per minute left to be applied to useful work under the regulation of the governor. As this engine can be started and stopped at a moment's notice, giving full power at once, and is free from the risks of a boiler explosion, it is peculiarly suited for use as a motor in a laboratory. The consumption of gas is seldom over 2*s.* 6*d.* worth per week for a 1-HP. engine. The engine as here exhibited contains many quite recent and very important improvements.

1968a. Model of a Steam Engine with **Glass Cylinders,** for demonstration, 1852. *M. Eugène Bourdon, Paris.*

1946. Sectional Model of a **Steam Engine,** with expansion. *Paul Lochmann, Zeitz.*

1948. Wall-diagrams illustrating the **Hot-air Engine.** *Prof. von Gizycki, Aix la Chapelle.*

1949. Wall-diagrams illustrating the **Gas Engine.** *Prof. von Gizycki, Aix la Chapelle.*

1950. Wall-diagram illustrating the **Steam Engine,** with continuous expansion. *Prof. von Gizycki, Aix la Chapelle.*

These diagrams are used in Prof. von Gizycki's lectures on description and theory of machines.

1968. Bailey's Patent Quadruple Engine House Recorder registers on a diagram, which is removed, examined, and replaced every 24 hours, the varying pressure of the boiler and speed of the engine during that time. It consists of a steam pressure gauge, and a rotary speed indicator which registers on the diagram round the revolving drum, an eight-day timepiece which actuates the drum and indicates the time, and a thermometer, all complete in French polished mahogany case, with closet for the safe keeping of tools, scientific instruments, &c.

W. H. Bailey & Co.

1978. Holt's Automatic Cylinder Drain Valves.

The object of this is to let out condensed or priming water from steam-engine cylinders. The valves open automatically at each exhaust, or when the engine stands, and remain open until the admission of steam, when they close, and prevent waste of steam.

Henry P. Holt, C.E.

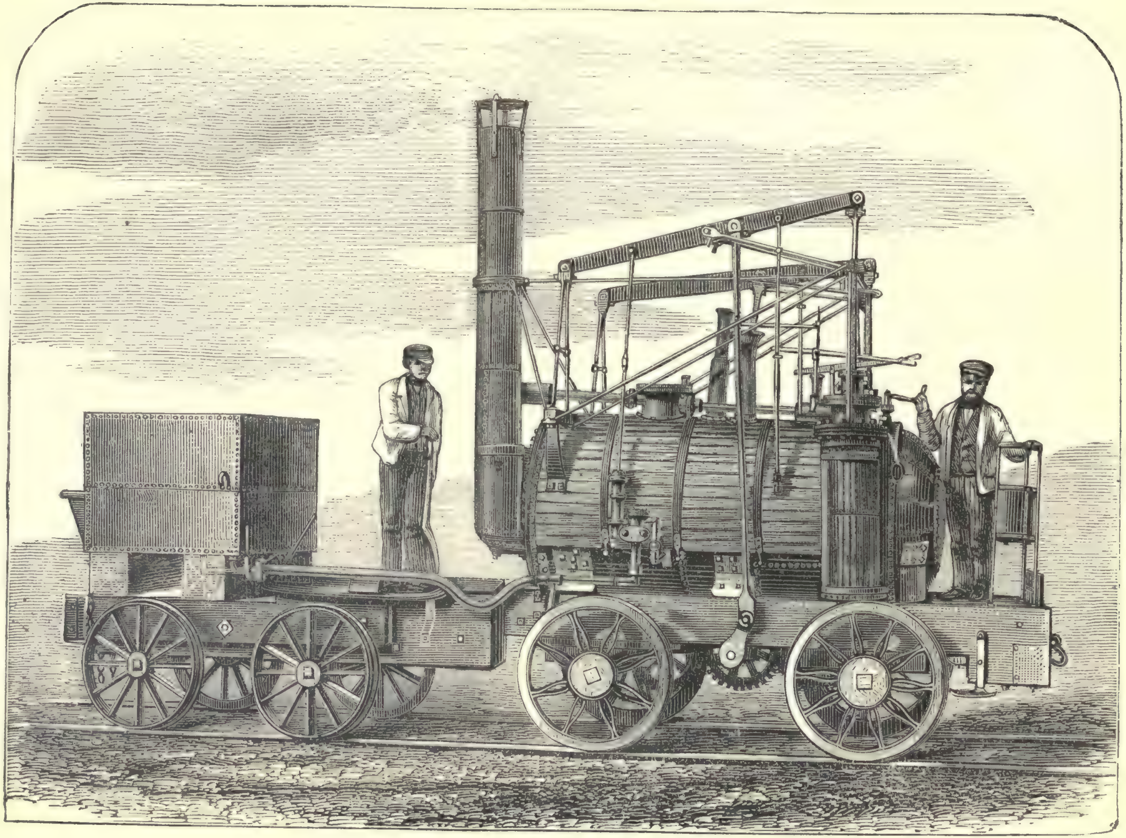
1979. Model of Dawes' Balanced Slide Valve.

The peculiar advantage of this consists in the mode of making an elastic joint between the relief frame and back of valve by means of a steel plate, secured to both in such a manner as to form practically one piece, thus avoiding leakage and the necessity of frequent attention. *Henry P. Holt, C.E.*

1982. McCarter's Patent Condenser, applicable to steam engines, and other purposes where a vacuum is required by the condensation of steam, without an air-pump being applied, and drawing its own injection water. *J. Wood.*

The condenser consists of two chambers, one above the other. The upper chamber (H) is for condensing the steam, the lower one (G), with the two

[*To face page* 456.]



" Puffing Billy," described under No. 1934a.

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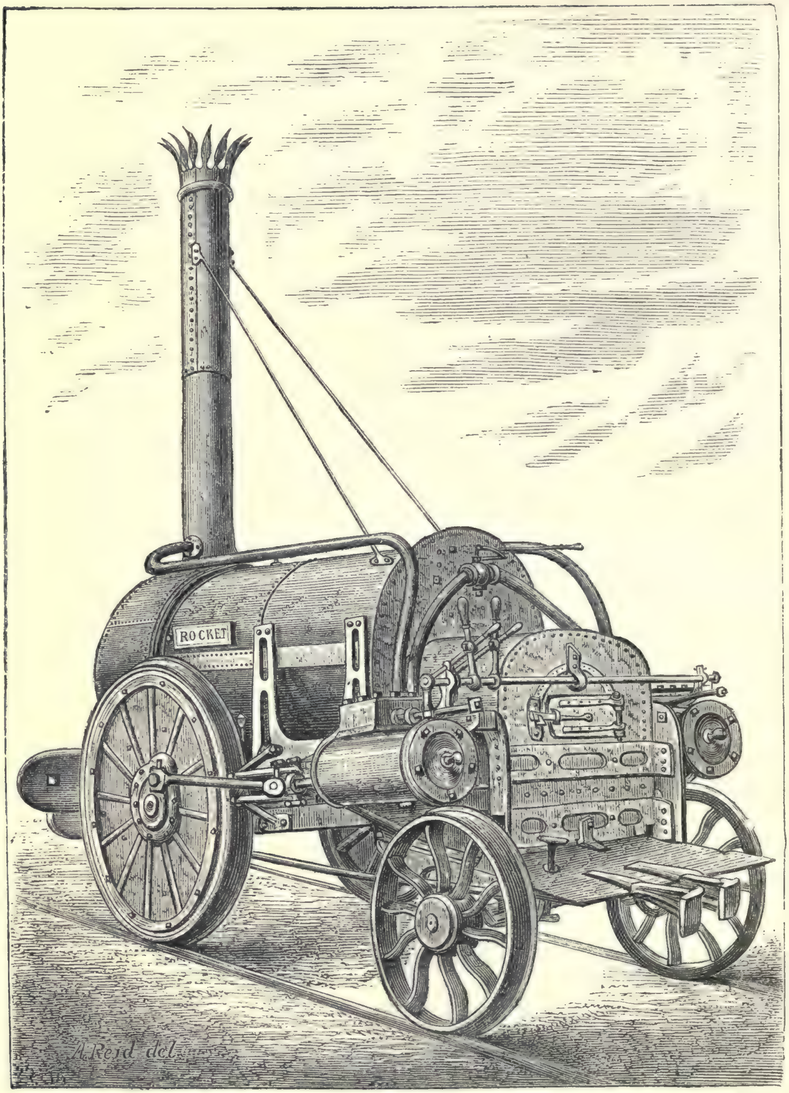

"The Rocket," described under No. 1934.

tappet valves (C and D) opening into it, removes the condensed water from the upper chamber into the hot water cistern, whence it flows away.

The exhaust steam from engine enters at A, meets the injection water entering at B, and is condensed, thus forming a vacuum, the water falling to the bottom of chamber (H). To remove this water, a vacuum is alternately created and destroyed, six times per minute only, in the lower chamber (G), by alternately raising the steam or water tappet valve (the steam supplying the tappet valve being reduced by reducing valve to $2\frac{1}{2}$ lbs. pressure). On vacuum being created in lower chamber, the water collected in upper chamber is drawn down through india-rubber foot valve (E); and on vacuum being destroyed in lower chamber, the water falls out through the delivering valve (F) into waste water cistern.

b. LOCOMOTIVES.

1936. Original Model of Trevithick's Locomotive Engine. (Trevithick's Patent, 1802.)
Bennet Woodcroft, F.R.S.

1934a. Puffing Billy, the oldest locomotive engine in existence, and the first which ran with smooth wheels on smooth rails, was constructed in 1813 by *Jonathan Foster*, under *William Hedley's* patent, for Christopher Blackett, Esq., the proprietor of the Wylam Collieries near Newcastle-upon-Tyne. This engine, after many trials and alterations, commenced regular working in 1813, and with tender and two trucks, a total load amounting to fifty tons ran, at an average rate of six miles an hour. This engine worked until the 6th June 1862, and was then purchased for the Patent Museum.
H.M. Commissioners of Patents.

1934. The **Locomotive Engine "Rocket,"** constructed, by Messrs. Stephenson & Co. in 1829, to compete with other engines on the Liverpool and Manchester Railway, where it gained the prize of 500*l.* The Liverpool and Manchester Railway was formally opened for passenger traffic on the 15th September 1830.
H.M. Commissioners of Patents.

Stephenson's Model of the "Rocket."
G. R. Stephenson.

2210d. Photographs of the first engine employed on a public railway, of the first and of the most modern railway coaches, and of the first two railway bills. *Alfred Marshall.*

2212g. Model of Central Rail Locomotive with its rail (1842). *Late Baron Séguier, Membre de l'Institut.*

2212f. Model of Railway with central rail, 1843.
Late Baron Séguier, Membre de l'Institut.

2212h. Model of Central Rail Locomotive, by Baron Séguier and Dumery, with part of the road, 1862.
Late Baron Séguier, Membre de l'Institut.

1952. Working Model, on a 1½ inch to 1 foot scale, of a four wheel locomotive engine. Built at Alexandria in 1862 for service of Egyptian Railway between Alexandria and Suez. Jeffrey Bey, C.E., Great George Street, Westminster.
South Kensington Museum.

The model represents an engine of the outside-cylinder "Stephenson" type, on four wheels, and is a tank engine of a peculiar form.

The water tank is hung beneath the boiler; the coal boxes are placed over the fire-box of the boiler.

To the model are attached the necessary accessories of a locomotive engine, viz., lifting screw jack with traverser, screw keys, fire bars, lights, stoking irons, &c., complete.

1953. Model, in wood and brass. Sectional working model of the cylinder, piston, slide-valve, eccentrics, link motion, and other parts of a locomotive engine. Jeffrey Bey, C.E., Great George Street, Westminster. *South Kensington Museum.*

This model also indicates the variable expansion and cut-off of steam in the engine cylinder.

1957a. Model of Goods Locomotive.
Museum of the Technological Institute, St. Petersburg.

1938. Model of Reversing Apparatus for **Locomotive Engines.** *Bennet Woodcroft, F.R.S.*

1939a. Model of Locomotive, of great adherent power, working by means of six clogs.
M. Adolphe Fortin Herrmann, Paris.

(This model belongs to the Conservatoire des Arts et Métiers.)

1939b. Frame containing photographs of the **first Engine employed on a public railway.** *A. Marshall.*

1934b. T. R. Crampton's Express Locomotive Engine. The peculiarities being a very low centre of gravity and large driving wheels with a minimum of overhanging weight, the whole of the moving machinery being on the outside of the engine. Designed in 1847. *Thomas Russell Crampton.*

Description of Locomotive Model.

The locomotive was designed by T. R. Crampton for high speed.

Previous to this engine being designed no express trains were run on the Continent. For this purpose it was selected in 1849 to commence an express service between Calais and Paris, since which period to the present time, 1876, the Northern of France express trains have been worked almost exclusively with this system of engine.

2212b. Dignity and Impudence (after Landseer).
F. W. Webb.

This photograph represents the largest and smallest locomotives employed by the London and North-western Railway Company. The following dimensions of them may be interesting :—

	Dignity.	Impudence.
Size of cylinders - - -	$17\frac{1}{2}$ in. × 24 in.	$4\frac{1}{4}$ in. × 6 in.
Diameter of driving wheels -	8 ft. 6 in.	$15\frac{1}{4}$ inches.
Gauge - - -	4 ft. $8\frac{1}{2}$ in.	18 inches.
Weight in working order - -	$28\frac{1}{2}$ tons	$2\frac{1}{2}$ tons.

2212h. Six Wheels coupled Mineral Engine. Size of cylinders, 17″ dia., 24″ stroke. Diameter of wheels, 4 ft. 3 in. Total weight in working order, 29 tons 11 cwt. *F. W. Webb.*

The barrel of the boiler and fire-box casing are of steel, and the axles and many of the working parts are also of steel.

2212i. Four Wheels coupled heavy Express Passenger Engines. Size of cylinders, 17″ diameter, 24″ stroke. Diameter of coupled wheels, 6 ft. 6 in. Total weight in working order, 32 tons, 15 cwt. *F. W. Webb.*

The frames, barrel of boiler, and fire-box casing, are of steel, and the axles and many of the working parts are also of steel.

2212j. Four Wheels coupled Passenger Engine, for heavy gradients. Size of cylinders, 17″ × 24″ stroke. Diameter of coupled wheels, 5 ft. 6 in. Weight in working order, 31 tons, 8 cwt. *F. W. Webb.*

The barrel of the boiler and fire-box casing are of steel, and the axles and many of the working parts are also of steel.

1942. Model of Agricultural Locomotive Engine, fitted with patent side-plate brackets. *Aveling and Porter.*

This represents one of Aveling and Porter's road locomotive engines. The *single* cylinder is placed on the forward part of the boiler, and is surrounded by a jacket in direct communication with it; the steam is taken into the cylinder from a dome connected with the jacket. Priming is by this means prevented, the use of steam-pipes either inside or outside the boiler is rendered needless, and a considerable economy in fuel is effected. The crank-shaft brackets are formed out of the side plates of the fire-box extended upwards and backwards in one piece, so as not only to carry the crank-shaft, but to provide bearings also for the counter-shaft and driving-axle, in the most convenient position. This arrangement produces a combination of much strength and lightness, reduces to a minimum the loss and annoyance from leakage at strained bolt holes, and unites all parts, peculiarly exposed to injury by jarring, with such firmness as to give almost absolute security against such injury on even very rough roads. The driving wheels are of wrought iron, and are fitted with compensating motion for turning sharp curves without disconnecting either wheel; they carry about 85 per cent. of the weight of the engine. The engine is steered from the foot-plate. The boiler is made of best quality plates, and tested with cold water to 200 lbs. on the square inch; the fire-box is of Lowmoor iron.

1947. Sectional Model of a **Locomotive.**
Paul Lochmann, Zeitz.

c. TURBINES AND WATERWHEELS.

1951. Turbine to act as prime mover for physical laboratories. Head of water necessary, 10–20 met.; measure of water, 1 lit. per sec.; effective power about 10 meterkilo.

Prof. Wüllner, Aix la Chapelle.

This turbine, with constant water pressure, the plan of which was made by Prof. Hermann, Aix la Chapelle, is exceedingly steady in its action, and thus is specially suited for apparatus that require a constant velocity of rotation. With the fall of 18 mètres available in air, and a water supply of about one litre per second, the effect of the machine is equivalent to one man's power.

1983. Fourneyron Turbine, $\frac{1}{5}$th scale, by M. Clair.

Conservatoire des Arts et Métiers, Paris.

1990. Working Model of Whitelaw and Stirrat's Patent Water-Mill Turbine. *Glasgow Mechanics' Institution.*

The water-mill acts on a principle similar to that of the well-known "Barker's mill," but the arms are bent, and otherwise shaped, so as to allow the water to run from the central opening out to the jet-pipes.

1991. Working Models of three sets of Waterwheels, viz., undershot wheel, overshot wheel, and breast wheel.

Glasgow Mechanics' Institution.

2151. Photograph of a waterwheel with paddles, floating by itself, and capable of being utilised on streams and navigable rivers. *Prof. Daniel Colladon, Geneva.*

A wheel on the above system has been at work for the last ten years on the Rhone near Geneva, with satisfactory results.

IV.—HYDRAULICS.

1994. The **First Hydraulic Press** ever made. Patented by Joseph Bramah, A.D. 1795, No. 2,045.

H.M. Commissioners of Patents.

409a. Professor James Thomson's V Gauge Notches, for measurement of water flowing in rivers or streams, shown together with the ordinary gauge notch of rectangular form.

Prof. James Thomson.

The V notch has been devised and brought forward chiefly for use in hydraulic engineering, as being more suitable than the rectangular notch for gauging the greatly varying flows of rivers and streams. If a rectangular notch is made wide enough to allow the water to pass in times of flood, the water flows in it, during long periods of dry weather, too shallow to be well suited for trustworthy measurement; but in the V notch the width of the flowing water varies proportionally with the depth. In the V notch the flow, while varying in quantity per unit of time, remains similar in its external configuration, and form of stream lines, at and near the notch, and it is only the magnitude of the configuration, and the velocity at homologous points, that vary when the quantity flowing varies. It results that the quantity flowing is proportional to the $\frac{5}{2}$ power of the vertical depth from the still water surface level down to the vertex of the notch. The apparatus exhibited shows two V notches, one *without floor*, and the other *with a level floor starting from the vertex of the notch.* The introduction of the floor allows of trustworthy gaugings being attained without the requirement of so deep a pool as is otherwise necessary. For further information reference may be made to British Association Report, Part I., Manchester Meeting, 1861.

1995. Weisbach's Apparatus, for illustrating experimentally the laws of **Hydraulics,** and for the determination of hydraulic coefficients. *The Royal Indian Engineering College.*

Large Reservoir, with fittings for attaching mouth-pieces under different heads. With hook gauges for marking the change of water level. *The Royal Indian Engineering College.*

Smaller Reservoir, for attachment to larger reservoir; used for experiments on large orifices and notches under constant head. *The Royal Indian Engineering College.*

Gauging Tank, fitted with **Hook Gauges.**
The Royal Indian Engineering College.

Reservoir and Long Channel, for illustrating the laws of flow in open channels.
The Royal Indian Engineering College.

Series of Mouth-pieces and Orifices for use with the reservoirs. Comprising—

3 large rectangular orifices and notches.
6 thin edged orifices of different forms.
6 conoidal and conical orifices.
6 orifices with partially suppressed contraction.
5 elbows, bends, and sudden enlargements.
1 pair of plates for radial current.

The Royal Indian Engineering College.

409g. Darcy-Pitot Gauge, or current meter used in Darcy and Bazin's researches on the flow of water in pipes and channels. This gauge gives the velocity at a definite point of the stream and without a time observation. *Prof. W. C. Unwin.*

2064b. Professor James Thomson's Jet Pump, with intermittent reservoir for drainage of low lands or shallow lakes by water power. *Prof. James Thomson.*

The jet pump, while working, must always have its full supply of water; but the intermittent reservoir allows of its varying its work according to the wetness of the weather.

The jet pump with intermittent reservoir is a contrivance for the drainage of flat marshy lands, or shallow lakes, in cases in which there is no outlet available low enough to allow of the water flowing away by its own gravitation in drains of ordinary kinds, but in which there is water power available from rivers or streams descending from higher ground in proximity to the low wet ground. The jet pump is not necessarily arranged in conjunction with an intermittent reservoir, but may be used alone in many cases for raising water by the power of other water descending to the available outfall level from above. A general notion may be formed of the mode of action of the jet pump by conceiving the action as being somewhat like that in a locomotive steam-engine chimney, with the substitution of an impelling jet of water instead of the impelling jet of steam, together with the substitution of water drawn from the low land instead of smoke drawn from the fire. The part corresponding to the chimney must have a narrow throat at the place where the jet enters, and must thence widen very gradually towards its outlet end. It is usually convenient to have it inverted, as compared with the chimney, so that the jet shall shoot downwards; and the discharging end of the pipe corresponding to the chimney must be immersed in the outfall water, so as to prevent any admission of air during the pumping action. The water is drawn up from the low ground by a suction pipe, terminating in a chamber surrounding the jet nozzle. Now, since the jet pump, when wanted to be applied for drainage, must be made large enough to do the work of flood times, it would be much too large to work continuously in dry weather, and, therefore, it is made to work intermittently, by the arrangement, in conjunction with it, of an intermittently flowing reservoir. The reservoir is made to receive the continuous but variable supply of water for power coming from the higher ground, and to give it out intermittently to the jet pump. The intermittent action is brought about in a very simple way by means of two syphons. The whole arrangement here described was contrived many years ago by Professor Thomson, and brought, with entire success, into practical use on the lands of William Forster, Esq., of Ballynure, Clones. It is free for general use wherever applicable, not being the subject of a patent.

1996. Working Model of a Hydraulic Ram, arranged with glass air vessels, so as to show the action of a column of air and pulsations of delivery valve. *K. W. Hedges & Co.*

2213. Apparatus for showing the **Motion** of **Fluids** through **long Tubes.** *T. Hawksley.*

V.—FIRE ENGINES AND PUMPS.

2053. Pneumatic Pump, with taps. Invented by 'sGravesande. *Prof. Dr. P. L. Rijke, Leyden.*

The taps are at each stroke of the piston turned 90° by an appliance in the form of a cross fixed to the handle. (*See* 'sGravesande's " Physices Elementa Mathematica," ed. III. vol. II., p. 591.)

2020. " A new Water Engine for **Quenching** and **Extinguishing Fires."** *H.M. Commissioners of Patents.*

This engine is made under patents No. 439, A.D. 1721, and No. 479, A.D. 1725, granted to Richard Newsham, pearl button maker, of London, and is one of the first engines in which two cylinders and an air vessel are combined and worked together so as to ensure the discharge of a continuous and uniform stream of water with great force. This invention of Newsham still exists in all fire-engines of the present day, with improvements in materials, workmanship, and the application of steam power.

2020a. Complete Working Model of the most Improved Form of London Brigade Steam Fire Engine, as now in daily use in the metropolis, constructed entirely by H. Nagy Effendi, Egyptian Government Pupil in the establishment of Shand, Mason, & Co. *Shand, Mason, & Co.*

2020b. Complete Working Model of the most Improved Form of London Brigade Manual Fire Engine, as in daily use in the metropolis. *Shand, Mason, & Co.*

1943a. Pulsometer (Hall's patent).
Hodgkin, Neuhaus, & Co., London.

Self-acting steam pump, a novel application of the general principle involved in Savery's engine, A.D. 1702. The result is produced by the pressure of the steam from the boiler upon the surface of the water in each chamber of the pump alternately, without the intervention of any steam piston or plunger, and the water is lifted into the chambers by a vacuum produced without injection or surface condensation. The action of the steam ball which governs the pulsations is purely automatic, and the moving parts, including four valves, are only five in number.

1967a. Pumping Machinery (being largely used for raising fluids, and the engine used as a prime mover.)
Hayward Tyler & Co.

The pumping machinery, Nos. 1967*a* and 1963, is distinguished for great simplicity of construction and durability of parts, Nos. 1964 and 1965, combined with the above, for obtaining a longer stroke, means of starting from the outside by a lever, and the obtaining of a "rest" at each end of the stroke to allow time for the pump valves to close easily.

1963. Model of a patent direct acting "Universal" steam pump, as used for pumping water from mines, or for other purposes where simplicity of construction and economy of space are matters of importance. *Hayward Tyler & Co.*

1964. Drawing showing a longitudinal and a cross section through the steam cylinder of "Universal" steam pump, showing steam piston with slide valve therein, and the arrangement of ports. *Hayward Tyler & Co.*

1965. Wood Model to show the action of a recent improvement in the mechanism of the "Universal" steam pump for high "lifts;" the slide valve being contained in a valve chest outside the cylinder, and allowing of the use of an ordinary steam piston, thus allowing a longer stroke without lengthening the cylinder. *Hayward Tyler & Co.*

1966. Drawing illustrative of the arrangement of slide valve, &c. for the "long stroke" "Universal" steam pump for high lifts. *Hayward Tyler & Co.*

1977a. Photographs (2) **of Frank Pearn's Double and Quadruple acting Steam Ram Pumps** for feeding steam boilers with water. Frank Pearn & Co., Manchester.
South Kensington Museum.

1993a. Davey's Compound Differential Expansive Pumping Engine. *Hathom & Co.*

The main slide valve spindle is attached to the centre of a differential lever, one end of which derives its motion from the engine, and reciprocates with the steam piston, whilst the other end is actuated by means of a subsidiary piston, caused to reciprocate in equal times by means of a double acting cataract governor. The movement of the cataract end of the lever is constant, and independent of the motion of the main piston of the engine, and has necessarily a lead in advance of that of the opposite end at the commencement of each stroke. With a constant load on the engine the lead will be constant and the cut off constant, but the slightest variation in the load causes a corresponding instant variation in the lead, and as a consequence the cut off takes place earlier or later, as the load is decreased or increased. The engine thus automatically varies the expansion to suit the varying conditions of resistance.

1993b. Davey's Hydraulic Pumping Engine. Worked by means of a natural or an artificial head of water.
Henry Davey.

In this engine there are no pistons, but the power is applied and the work done entirely with plungers. The power plungers are stationery, and are made to serve as pipes to convey the water from the valve box (to which they are fixed) to the inside of the pump plungers ; these latter forming the power cylinders and being connected to each other by side rods passing outside the valve box. In this way the forcing stroke of one pump plunger causes the suction stroke of the other, and *vice versâ.* In "dip" workings in collieries these engines are used to raise water to the main pumping engines, the motive water in this case being supplied from the rising main of the main engine. In hilly mining districts, too, water drawn from a high level is conducted by pipes into the mines and then used to raise water to the surface, thus avoiding the necessity for steam power. The valves of the engine are worked without any metallic connexions by means of water pressure through a small valve actuated by Davey's differential gear.

2062. Model of Force Pump. *Prof. W. F. Barrett.*

2063. Model of Ordinary Water Pump.
Prof. W. F. Barrett.

1989. Model of Sand Pump.
The Council of King's College, London.

1989a. Air Water Pump, by Jagn.
R. Nippe, St. Petersburg.

2064. Model (to scale) **of Centrifugal Pump.**
Lawrence and Porter.

This pump has been patented by Messrs. Lawrence and Porter. The chief feature of the patent is the arrangement of making one side of the casing removable. The advantages of this system are as follows : By taking off the movable side, the disc or "fan" can readily be examined or removed in a few minutes without in any way disturbing or interfering with the suction or delivery pipes. This is found in practice to be a very great advantage.

Also by making the side removable the amount of both machine and hand work in fitting up the pumps is greatly reduced. The size and weight of any pump (to raise a given quantity of water) are considerably diminished, so that pumps made on this system are far more compact and portable than any centrifugal pumps of the ordinary construction.

One of Lawrence and Porter's pumps with discharge pipe six inches diameter, and weighing only 3½ cwt., is capable of raising 900 gallons of water per minute, or 54,000 gallons of water per hour. Many of these pumps are now actually at work with highly satisfactory results, and they have received favourable notice by the scientific press.

In the model the side can be removed by simply pulling it gently in a horizontal direction, as the nuts are merely for show, and do not hold it on, and by loosening the small screw in the pulley the disc and spindle can be instantly withdrawn for examination. The patentees will be glad to give further information.

2064a. Appold's Original Centrifugal Pump and Four trial Discs. *The Council of King's College, London.*

2066. Archimedean Screw, with glass screw to show the raising of the water. *Elliott Brothers.*

VI.—RESERVOIRS OF ENERGY.

Boilers, Injectors, Pressure Gauges, etc.

1969. Drawing, water-colour, on a ½-inch to 1 foot scale. A pair of double flue tubular Cornish boilers for high-pressure. Adamson's patent. D. Adamson & Co., Engineers, Hyde Junction, Manchester. *South Kensington Museum.*

Two of these boilers were lent to H.M.'s Commissioners for the Vienna Universal Exhibition of 1873, for use in supplying steam to drive the British machinery exhibited in motion.

The drawing shows front or firing and elevation of boilers; longitudinal elevation with brick setting.

Longitudinal sectional elevation, showing arrangement of flues; blow-off, feed, and other pipes. Brick settings.

Two cross sections.—One through centre of boilers; the other through back end, showing brick setting, flues, &c.

1970. Sectional Model, in brass, showing the tubular arrangement, water spaces, and circulation of Richardson's patent vertical high-pressure steam boiler. Robey & Co., Limited, Engineers, Lincoln. *South Kensington Museum.*

1971. Drawing of Richardson's patent vertical high-pressure tubular steam boiler. Made by Robey & Co., Limited, Engineers, Lincoln. *South Kensington Museum.*

The drawing shows a sectional elevation indicating the water circulation and the direction of the fire and products of combustion. Also a sectional plan of the boiler.

1972. Drawing, on a $\frac{3}{4}$-inch to 1-foot scale, of Howard's patent tubular safety land boiler; for high-pressure. J. and F. Howard, Engineers, Bedford. *South Kensington Museum.*

The drawing illustrates a front view of the boiler; longitudinal section, plan, and cross section.

On a scale of $\frac{1}{4}$ full size is shown the detail of the water tube connexions.

These boilers are made by the Barrow-in-Furness Shipbuilding Company.

1973. Drawing, on a $1\frac{1}{2}$-inch to 1-foot scale, of Messrs. A. Chaplin & Co.'s patent vertical tubular high-pressure steam boiler. Alexander Chaplin & Co., Engineers, Glasgow. *South Kensington Museum.*

The drawing shows vertical sections. Two plans of the disposition of the upper and lower tubes.

1974. Drawing, sectional, on a 3-inch to 1-foot scale, of an improved vertical high-pressure steam boiler, having horizontal water tubes with "Nozzle" ends, to assist the water circulation. From the construction of the tubes with Nozzle ends this boiler is called the "Nozzle" boiler. Reading Iron Works Company, Limited, Reading. *South Kensington Museum.*

The drawing shows a sectional elevation of the boiler, and a sectional plan of the arrangement of the tubes; the circulation of the water, together with the direction of the fire and products of combustion.

1975. Steam Pump. Horizontal direct-acting steam engine and pump for feeding steam boilers with water, or for pumping and draining purposes. Cope and Maxwell's Patent. Hayward Tyler and Co., 84, Whitecross Street, E.C.

The steam cylinder is 5 inches in diameter. The stroke is 7 inches.

The pump plunger is 3 inches in diameter.

The valves are balls of india-rubber.

The pump will raise 2,000 gallons per hour to a height of 120 feet vertically. *South Kensington Museum.*

1976. Three **Models,** in brass, showing in section the arrangement of Giffard's patent injector for feeding steam boilers with water. Sharp, Stewart, and Co., Engineers, Manchester, and Victoria Street, S.W.

a. Giffard's patent injector, in section.

b. Giffard's injector, in section, with the patent adjustment of Messrs. Robinson and Gresham.

c. Giffard's injector, in section, with Seller's patent adjustment. *South Kensington Museum.*

1977. Accessories.—Pressure Gauges, for **Engines, Boilers, &c.** Schäffer and Budenberg, 23, Lower King Street, Manchester.

a. 5-inch Pearson's patent lubricator for steam cylinders, and other working parts of machinery.

b. Mercury vacuum gauge for condensing steam engines.

c. Thermometer for measuring high temperatures.

d. Bourdon's patent steam-pressure gauges, for high and low pressure boilers.

e. Bourdon's patent vacuum gauges.

f. Schäffer's patent steam-pressure gauges for high and low pressure boilers. Two of these gauges are in section showing interior arrangement.

g. Schäffer's patent vacuum gauges, for condensing steam engines, &c.

h. Schäffer's patent hydraulic-pressure gauges, with maximum indicators.

i. Blast furnace gauge, mercury; indicating 6 lbs. pressure.

k. 7-figure counter, in section, for counting steam engine revolutions and speeds of machinery. *South Kensington Museum.*

327a. Patent Water Gauge for steam boilers, independent of level or distance. *John Nicholas.*

This instrument is for indicating in an office or ship's cabin the quantity of water in the boiler or other vessel to which it is attached. The boiler may be any distance from the office, and upon any relative level. The small tank represents a portion of a boiler to which the stand pipe is attached; in the centre of the stand pipe is a brass tube, open at the top into the steam space, and communicating at the bottom with the right-hand union. The left-hand union opens directly into the water space. The right-hand union is connected by a lead pipe with the top part of the gauge glass, the other by a similar tube with the bottom of the glass, forming a continuous tube, one end of which is open to the steam and the other to the water space. This system is now entirely filled with water, which will always have the same level inside the brass tube as in the boiler, and any movement in the boiler will cause a corresponding motion in the brass tube, such movement being continuous throughout the system. A small quantity of oil is placed in the gauge to show readily this movement, and the line of contact in the glass tube represents the position the of water in the boiler.

1977a. Indicator of Pressure, marking in points, thus avoiding the difficulty of propulsion.
Marcel Deprez, 16, *Rue Cassine, Paris.*

1977b. Model of Indicator, for steam-engine.
Marcel Deprez, 16, *Rue Cassine, Paris.*

1977c. Dianemometre, or rule, showing the graphic solution of indicator diagrams. *Marcel Deprez*, 16, *Rue Cassine, Paris.*

VII.—REGULATORS.

1997. Spherical Governor for Steam Engines. Patented by John Bourne. *H.M. Commissioners of Patents.*

1998. Governor for Steam Engine. *Gros, Paris.*

1998a. Gyrometric Governor for Steam Engines.

Messrs. Siemens Brothers.

It consists of an open cup of parabolic shape, fixed upon a vertical spindle, and caused to revolve within the closed chamber containing the liquid, the bottom of the cup being open and always immersed below the surface of the liquid. When the cup is made to revolve rapidly, the liquid contained in it rises round the sides of the cup and sinks in the centre, the surface of the liquid assuming the inverted parabolic form ; and on reaching the edge of the cup it overflows into the surrounding chamber, while at the same time a fresh supply of liquid is drawn into the cup through the opening in the bottom ; and the power absorbed in putting the overflowing liquid into motion offers a continuous resistance to the rotation of the cup. On a level with the edge of the cup, a series of fixed vanes are placed round the circumference of the external chamber, and a corresponding set of blades are also fixed round the outside of the cup just below the rim, so that the sheet of liquid overflowing from the edge of the revolving cup is thrown against the vanes, and by these is thrown back against the blades on the cup, whereby the overflowing liquid is made to offer an additional resistance to the rotation of the cup.

The internal radial arms uniting the shell of the cup to the centre boss serve to communicate the rotary motion to the liquid inside the cup, while the bottom of the external chamber is provided with a number of radial ribs, for the purpose of checking rotary motion in the liquid outside the cup.

So long as the cup is driven at a constant speed, the overflow is constant, and produces an absolutely constant resistance ; and, hence, if the cup be driven by a constant driving power, independent of the engine, its speed is as uniform as that of a chronometer, within a very small margin of variation, which is definitely fixed ; and it continues revolving at an unchanging speed, totally independent of the engine, and consequently affords the means of forming a governor for controlling the speed of the engine to a constantly uniform rate.

1998b. Chronometric Governor for steam, land, and marine engines, water wheels, turbines, &c. *Dr. C. W. Siemens.*

1998c. Gyrometric Governor for a steam engine (size adapted for a 4″ steam pipe). *W. D. Scott-Moncrieff.*

This is an apparatus in which the centrifugal force of a fluid is applied so as to regulate the aperture of a throttle valve through the movements of a loaded piston. It consists of two chambers containing fluid, and communicating with each other through a turbine wheel with four or more straight radial arms. The speed of this wheel depends upon that of the prime mover by which it is driven, and the pressure in the front chamber is dependent upon its velocity, and its variations open and shut the throttle valve.

In the pendulum governor the centrifugal force and the speed necessary to maintain it vary with the different planes of rotation due to different positions of the throttle valve. Such an apparatus can only be correct for one position, and errors of speed must occur for every change in the power of the prime mover or the work it is performing, unless these vary simultaneously and equally. In this governor the centrifugal force of the fluid remains in a fixed ratio to the speed of the engine, and the length of the connexion to the throttle valve varies with the altered length of the fluid column supporting the piston. By adjusting the load upon the piston any speed which the engine is capable of maintaining can be given and will remain constant for all variations of power and work. An index of the speed may be obtained by attaching a glass or Bourdon gauge to show the varying pressures.

1998d. Governors for **Turbines** and **Steam Engines** (J. G. Bodemer's), with apparatus for graphic representation.
Bock & Handrick, Dresden.

1999. Model of Holt's Injection Water Regulator.

This is an automatic valve for regulating the supply of injection water admitted into steam-engine condensers, according to the requirements of the vacuum. It is useful in engines having a very variable load, and where water is taken from water-works for condensation. *Henry P. Holt, C.E.*

1999a. Series of **Models** of **Governors,** &c. for **Steam Engines,** invented by Thomas Silver, of Philadelphia.
H.M. Commissioners of Patents.

a. Differential marine governor.
b. Method of adjusting pneumatic governors when in motion.
c. Marine governor.
d. Combined isochronal and centrifugal governor.
e. Model showing T. Silver's earliest attempts at combining centrifugal and isochronal principle in his marine governor.
f. Reversible link motion.
g. Method of equalising the tension of a spring when in action.
h. Marine governor.
i. Marine governor.

2000. Model showing the effect of hanging the **Arms** of a **Governor** from different points with respect to the axis of rotation. *Jeremiah Head, M.Inst.C.E.*

By turning the horizontal sheave upon the model with gradually increasing velocity, it will be seen that the cross-armed, or approximately parabolic governor, goes through its range with the least variation of speed. Next in efficiency is that wherein the arms are hung from the central axis, whilst the very common form wherein the arms are hung externally is the least efficient, or, in other words, permits the greatest variation in speed between fully opening and fully closing the throttle-valve.

Apparatus for feeding Steam Boilers.
M. Cleuet, Paris.

2001. Drawing, half the actual size, of a **Regulator** for a **25 Horse-power Boiler.** *M. Cleuet, Paris.*

This appliance is fixed to the inside of the furnace with an inclination of a few centimetres, in such a manner that the plane of the water level proper to be maintained passes through the upper tube at a point about half its length.

Connected with the boiler, on one hand, and with the feed pipe on the other, this appliance constitutes a kind of weight thermometer, the expansion and contraction of which depend upon the position of the water level in the boiler, and determine the flow by a discharge of the excess of water injected by the feed pump, which works uninterruptedly.

2001a. Two Proell's Patent Regulators for machinery, and three diagrams. *Dr. R. Proell, Görlitz.*

2010. Gyrograph. *Prof. von Gizycki, Aix-la-Chapelle.*

This instrument serves in investigating the degree of inequality in the velocity of rotation of machine-shafts. The vertical deflections of the pencil from its lowest position are proportional to the increase of angular velocity of the shaft under examination. The instrument is driven by the latter by means of disc and cord.

VIII.--THE APPLICATION OF THE PRINCIPLES OF MECHANICS TO MACHINERY AS EMPLOYED IN THE ARTS.

2019b. Drawing of a connecting motion as applied to double screw boats. *M. Chas. Bourdon, Paris.*

2019c. Model of Connecting Motion, joining the apparatus recommended in the Mulhouse manufactories.

M. Engel Dolfus, Paris.

This model belongs to the "Conservatoire des Arts et Métiers." Each apparatus of which it is composed has a special direction for its erection.

2021. Machine for **Winding Cotton** into **Balls.** Invented by Sir Marc Isambard Brunel in 1802.

H.M. Commissioners of Patents.

By the invention of this machine the use of cotton for sewing became universal, as before its invention linen thread or occasionally cotton, always in skeins, had been used.

2022. Model of **Machine** for **Carving Wood** and other **Materials.** Patented by Thomas Brown Jordan, A.D. 1845, February 17th, No. 10,523. *H.M. Commissioners of Patents.*

2025. The first **Machine** constructed for **Printing** and **Numbering Railway Tickets.** Invented and patented by Thomas Edmondson. *H.M. Commissioners of Patents.*

2031. Model of **Vauloue's Pile-driving Machine,** made by Jas. Ferguson, Esq., F.R.S. (the astronomer).

Bennet Woodcroft, F.R.S.

Vauloue's engine was used for driving the piles of old Westminster Bridge in 1739 and following years.

2113. Working Model of a steam pile-driving engine for submarine foundations, and other work. Sissons and White's patent. Sissons and White, Hull. *South Kensington Museum.*

This model, on about ½-inch scale, is a complete working model of a steam pile-driver. The winch to raise the monkey by an endless chain is driven by frictional gearing by the engine, which represents a high-pressure inverted-cylinder direct-acting engine, having slide valve, eccentric, flywheel, and force pump for feeding the boiler with water. The boiler represents an upright tubular boiler for working at high pressure.

2026. Model of **Large Iron Shears.** Constructed by Messrs. Day & Co., of Southampton, for the Government Dockyards. *H.M. Commissioners of Patents.*

2027. Model of a **Hoist** or **Lift.** Patented by Thomas Silver in 1872. The principle of this invention is applicable to ascending gradients. *H.M. Commissioners of Patents.*

2027a. Model of Spouts used in Sunderland Docks for loading vessels with coal. *River Wear Commissioners.*

2027b. Model of Coal Drops used in Sunderland Docks for loading steam colliers with coal. *River Wear Commissioners.*

2027c. Model of **Apparatus** for **raising Heavy Spherical Bodies.** *Bennet Woodcroft, F.R.S.*

2028. Original Traversing Lifting Jack. Patented by George England in 1839. *H.M. Commissioners of Patents.*

2029. Four original Models showing methods of **converting Rectilinear** into **Circular Motion** as substitutes for the crank. Patented by James Watt in 1781.
H.M. Commissioners of Patents.

2030. Bar Lathe used by James Watt.
Bennet Woodcroft, F.R.S.

2030a. Circular Rest, for turning spheres nearly up to the full diameter of the lathe. The Rest being also adapted for holding all kinds of plain tools or the "drill," "universal," and "eccentric" "cutting frames," &c., with overhead motion. Invented by the exhibitor. *Tyssen Amhurst.*

2030b. Spherical Chuck (with six extra collars), for finishing spheres and chucking them for ornamental and other purposes. Invented by the exhibitor. *Tyssen Amhurst.*

2030c. Specimen in ivory turned by the above apparatus, consisting of a series of spheres detached one within the other, in Chinese fashion. *Tyssen Amhurst.*

2030d. Specimen of ivory turned with the above circular rest in conjunction with spiral apparatus, &c., by Mrs. Amhurst.
Tyssen Amhurst.

2032. Instrument for **dividing** and **ruling** the **Brass Meridian Rings** of **Globes,** made by Jas. Ferguson, Esq., F.R.S. (the astronomer). *Bennet Woodcroft, F.R.S.*

2037. Photograph and Model representing an Hydraulic Canal Lift at Anderton, in Cheshire, constructed by Messrs. Emmerson, Murgatroyd, & Co., of Stockport and Liverpool, for the Trustees of the River Weaver Navigation, from the designs and under the superintendence of Mr. Edwin Clark and Mr. Sidengham Duer. *Sidengham Duer, B.Sc.*

This lift affords an easy and expeditious means of transferring laden barges between the Trent and Mersey Canal, and the River Weaver, instead of the tedious and costly process, previously in use, of transhipping goods from one set of barges to another. The canal is on the top of a bank, and the river is 50 feet 4 inches below it. By means of the lift two barges can be transferred from the river to the canal, and two others from the canal to the river, in eight minutes; whereas in a chain of locks, where the difference of level is the same, only half that work can be performed in an hour and a half. It is pre-eminently useful wherever water is scarce, as it only takes about one per cent. of the water from the upper level which would be used if a chain of locks had been employed. The photograph is from the work itself, while the model is only intended to show how one of the troughs, having taken a depth of 6 inches of water over its area from the upper level, descends to the river, and in doing so lifts the other or lighter one nearly to the level of the canal by means of a central vertical hydraulic ram under each of the troughs without the employment of any other power. The rest of the operation is performed by a small steam engine. It was opened for public traffic by the trustees of the Weaver in July last, and has been in constant and successful operation since that time. The whole apparatus and other works in connexion with it are fully described by the exhibitor, and its applicability for lifting large ships is discussed in the "Minutes of the Proceedings of the Institution of Civil Engineers."

2038. Somerville's Machine for charging and drawing gas retorts by steam power. *John Somerville.*

It is constructed to run along the floor of retort house in front of retorts upon a line of rails or tramway, and consists of a platform on wheels, upon which is fixed a boiler and engine, which propels it and gives motion to the various parts. On the same platform is erected an upright frame, which serves as a support to the cradle or secondary platform carrying the scoop for charging or filling, and the rake for drawing the retorts; on top of frame is a receptacle (over the scoop) which is supplied with coals from another receptacle below by means of an elevator or Archimedean screw, whereby the scoop is filled with coals. The rake is attached in a similar manner to the scoop, and is propelled and withdrawn in the same way.

2039. Model of a **Californian Stamping Mill.**
Royal Saxon Mining Academy, Freiberg.

Model of Stone Breaking Machine.
G. H. Goodman.

2041. Machine for **Engraving** duplicates of **Medallions, Sculpture, &c.** (J. Bates' Patent, 1823.)
Bennet Woodcroft, F.R.S.

The object of this machine is to copy or engrave on metal plates an exact representation of medals, sculpture, and other works of art executed in relief.

2044. Model of **Nasmyth's Direct-action Steam Hammer.** (Nasmyth's Patent, 1842.)
H.M. Commissioners of Patents.

2044a. Photograph of the original sketch of Nasmyth's Steam Hammer. *James Nasmyth.*

This rapid sketch made on the morning of November 24th, 1839, embodies the original ideas of the invention of the steam hammer; it contains the main features and details, which have proved so satisfactory in practice as to be retained to the present time.

2045. Drawing of a **50-ton Double-action Steam Hammer,** supplied to the Russian Government for their gun factory at St. Petersburg. *Thwaites and Carbutt.*

Diameter of cylinder, six feet six inches; length of stroke, twelve feet six inches; total height from ground line, fifty feet.

Allen's Steam Striker. *J. W. Thomas.*

2045a. Model of a Friction-Hammer. *John Tille, Prague.*

This model is 72 cm. high, 42 cm. broad, and 21 cm. in length, and has been executed after the pattern of the friction-hammer constructed in the Royal Prussian Machine Workshops at Dirschau, where the exhibitor, in 1858 and 1859, was employed with the construction of the incline between Elbing and Osterrode.

With reference to this model it is to be observed that the small cog wheels fixed on the revolving shafts of the friction-rollers have only been attached for the purpose of putting the model in motion with a crank.

2045b. Model of a Spring or Elastic Hammer. *John Tille, Prague.*

These favourite spring-hammers, if in quick motion, effect a very powerful stroke; if in slow motion, a moderate stroke, the regulation of which is obtained by a treadle and a draw-pole, by means of a tension roller supported by levers. If the movement is stopped, the tension roller acts as a brake-weight.

In recent times, spring-hammers of this form are manufactured by Messrs. Auth. Fetn, and Deliege, at Liége.

2045c. Model of a Punching Machine. *John Tille, Prague.*

This model is constructed after Borsig's pattern, in which the balancing punch is moved forwards by a crank and wheels, by means of a movable press-bar.

2045d. Model of Parallel Shears. *John Tille, Prague.*

The movable cutting blade is fastened to a well regulated sliding piece, and moved by a crank and wheels by means of a draw-bar. This model is arranged at the same time to be worked by means of leather straps.

2045e. Model of Circular Shears, with cast ribbed frame. *John Tille, Prague.*

2045f. Model of Circular Shears, with concave cast frame. *John Tille, Prague.*

These two models, the circular cutting blades of which are fastened on spindles, and put in motion by means of wheels and cranks, illustrate chiefly the solidity and elegance of the concave casting as compared with the ribbed casting.

1980. Model of Dawes' and Holt's Hydraulic Shears.

In order to avoid buckling or bending either half of plate cut in two, a strip of metal equal to the thickness of the plate is sheared out of the plate, and the gap thus formed is utilised to allow the plate to pass the tie connecting the upper and lower blades; this machine can thus cut any size of plate. *Henry P. Holt, C.E.*

2046. Circular Knitting Machine. (J. A. Tielen's Patent, 1842.) *Bennet Woodcroft, F.R.S.*

2047. Models of **Chinese Agricultural Implements** (9), small mill, &c. *Bennet Woodcroft, F.R.S.*

2048. Model for showing the **Curves** of **Screws.** *Bennet Woodcroft, F.R.S.*

2050. Traction Dynamometer, used for ascertaining the draught of carts, waggons, and all agricultural implements that are drawn by horses. Also, for determining the resistance of roads and streets. *Royal Agricultural Society of England.*

The instrument is harnessed just like a horse to the implement it is desired to test, and being itself drawn along by one or more horses it registers the total work done in passing over any given distance, the mean and extreme tractive force, the pressure on the back of the horse, and the lateral pressure in such implements as reaping and mowing machines. First used at Bedford, 1874. Designed and made for the society by its consulting engineers, Messrs. Eastons and Anderson. *See* Journal of the Royal Agricultural Society of England, No. XX., part 2, page 678.

2051. Appold Friction Dynamometer, of 100 horse-power, used for measuring the work done by steam engines and other prime movers. *Royal Agricultural Society of England.*

The prime mover to be tested is coupled to the main shaft of the dynamometer, the friction breaks of which are loaded in proportion to the power it is desired to develop. The instrument registers the number of revolutions made in a given time, and this, together with the known weight on the breaks, furnishes the data for calculating the work done by the prime mover. This powerful instrument was constructed by the consulting engineers of the society, Messrs. Eastons and Anderson, for the trial of steam ploughing and traction engines at Wolverhampton in 1871.

2053a. Pneumatic Intercepting Apparatus for sending and receiving message carriers in pneumatic despatch tubes of 3 inches diameter, to be worked on the circuit system. *Messrs. Siemens Brothers.*

2052. Diplograph. Writing machine for the **Blind,** by which writing in relief and ordinary writing are performed at the same time. *Ernest Recordon, Geneva.*

2054. Dr. Thursfield's Patent Writing Frame, for enabling the Blind, and persons with defective or failing sight, to

write; and for facilitating writing in darkness or an unsteady light.
Elliott Brothers.

By means of Dr. Thursfield's apparatus anyone can write with equal facility in light and darkness. For those with defective or failing sight it is of the utmost value at all times, as when used in ordinary daylight no writing is visible, and the involuntary following of the writing by the eye is prevented. In cases of incipient cataract, and other ophthalmic diseases requiring rest, or after operations on the eye, it has been found a most valuable therapeutic agent. To literary men, travellers by railway or steamboat, and others compelled often to write in a bad or unsteady light, the invention will prove or great service. No ink or pencil is required, but the writing is equally legible and indelible. The mode of using the apparatus is very simple, and where any sight remains will at once be comprehended and found easy of execution.

2054a. Peters's Machine for Microscopic Writing, combining Ibbetson's Geometric Chuck.
Royal Microscopical Society, London.

With this machine any combination of bicycloid curves can be produced on a scale wonderfully minute. Many beautiful and complex designs of this kind have been engraved on glass with remarkable precision, in the space of a circle the fiftieth of an inch in diameter.

A disc the one-hundredth of an inch in diameter appears to the unaided eye as a mere point, yet that point, not larger than the full-stop of ordinary print, will contain five circles each, the three-hundredth of an inch in diameter, and in a circle of that size (that is, about the size of a transverse section of a hair of the human head) the Lord's Prayer is written and can be read. It has also been legibly written in the three hundred and fifty-six thousandth part of an inch. In this specimen the writing is so small, that, in similar characters, the Bible and Testament together (said to contain 3,566,480 letters) could be written twenty-two times in the space of one English square inch.

The name and address of Mr. "Matthew Marshall, Bank of England," has been written in the two-and-a-half millionth part of a square inch.

2054b. Facsimile Drawing and Writing Apparatus.
S. F. Pichler, London.

2055. Apparatus for filling **Manometer Tubes** with **Mercury** to any height.
Prof. Dr. R. A. Mees, Director of the Physical Laboratory of the University of Groningen.

The end of an india-rubber tube is screwed into an opening in the base of the manometer. A wooden vessel filled with mercury is elevated by means of a vertical iron rod to a height nearly corresponding with that desired in the manometer tubes. With the aid of a piece of wood, which is plunged into the wooden vessel, the exact adjustment of the mercury to the required height in the manometer can be effected.

2056. Diagrams illustrating the principles adopted in constructing **Wood-planing Machines.** These diagrams are used in lectures on Applied Mechanics at the I. and R. High School of Agriculture and Forestry, Vienna.
Dr. William Francis Exner, Vienna.

In the forestry section of the above school, series of lectures on the mechanical technology of wood-working are delivered annually. These are attended by foresters who wish to become qualified for the post of manager of wood-working establishments. For these lectures, diagrams of all sorts of tools and machinery for wood-working, are prepared. The examples shown form only the first part of the series.

2057. Model of **Lever Plough, with 6 shares,** for ploughing by steam. (Fowler's system, reduced to one-tenth.)
M. Digeon, Paris.

2059. First Type-distributing Machine, invented by Alexander Mackie. *John Maclauchlan.*

591. Small Wooden Model of Prof. Colladon's new Air and Gas Compressors (patented), used for the great St. Gothard Tunnel. *Prof. Daniel Colladon, Geneva.*

This system of compressors refrigerates air and gases simultaneously with the compression, and all the movable parts are kept cold, whatever may be the rapidity and force of compression. This system has been applied to several industrial purposes. It is the system of air compressors used exclusively in the boring of the great St.Gothard tunnel (length 14,920 mètres). At the extremity of this tunnel 30 of these compressors give 40 cubic mètres of air per minute, under the pressure of seven atmospheres, for the aëration of the tunnel, and the working of 60 boring machines and other apparatus, and eight other compressors supply air at 14 atmospheres for compressed air locomotives. *See* **2060.**

2060. Drawings of the air compressors on the Colladon system, employed in boring operations at the St. Gothard.
Prof. Daniel Colladon, Geneva.

2061. Models, Twenty-seven, for teaching machinery, executed by M. Schröder, of Darmstadt. *Prof. Pigot, Dublin.*

2065. Hook's Universal Joint, by which a shaft can be kept in rotation at any angle. *Elliott Brothers.*

2067. Steam Thermometer, for testing temperature of steam in the supply pipes. *Elliott Brothers.*

It consists of a thermometer the bulb of which dips into an iron cup containing mercury and oil. By this means the bulb is protected from breakage by pressure, and the thermometer can be removed at any time without letting off steam.

2068. Air Bell.
The Committee, Royal Museum, Peel Park, Salford.

An apparatus consisting of a metal tube 30 feet long, with a percussion pump at one end and a clapper at the other, which rings a bell whenever the piston is struck.—[Supposed to be the invention of the late Mr. Gavin M'Murdock, of Soho, Birmingham.] Made by the late Richard Roberts, C.E., of Manchester, 1840.

2069. Parallel Motion.
The Committee, Royal Museum, Peel Park, Salford.

Consisting of one wheel revolving within another of double its size, and carrying a pin whose centre, coinciding with the pitch line of the lesser wheel, traverses a straight line equal to the diameter of the larger.—[The invention of the late Mr. James White, of Manchester.] 1842.

2073. Apparatus for supposed **Perpetual Motion,** used by Dr. Thomas Young. *The Royal Institution of Great Britain.*

A wheel supposed to be capable of producing a perpetual motion, the descending balls acting at a greater distance from the centre, but being fewer in number than the ascending ones. "Lectures on Natural Philosophy," by Thomas Young, M.D., 1807.

2074. Model of Parallel Motion, consisting of three parts only. *William Hayden.*

This parallel motion depends on the properties of a right-angled triangle where the sides are as 3, 4, and 5. The longer radial arm being the less of the two sides containing the right angle, and the shorter radial arm half the longer of such sides, while the side of the triangle connecting the arms corresponds to the remaining half of such longer side. The distance between the fixed centres corresponds to the longest side of the triangle.

The line of motion is perpendicular to the straight line joining the fixed centres, and on the centre of the shorter radial arm; it is limited by the motion of the less radial arm through the less of the acute angles of the triangle first before referred to. The point giving the parallel motion is found by drawing a perpendicular from one of the acute angles of an isosceles triangle, where each of the equal sides is to the base as 5 to 8 (the other acute angle and the obtuse angle being connected to the two radial arms), to the perpendicular on the centre of the less radial arm.

2075. Parallel Motion; invented by the late Richard Roberts, C.E., Manchester; the peculiarity consists in the fixed centres being in the plane of the parallelism.
The Committee, Royal Museum, Peel Park, Salford.

2076. McKay's patent Equilibrium **Drilling Tools,** with specimens of work. *Menzies & Blagburn.*

This apparatus is designed to permit circular holes of any size to be bored out with mathematical accuracy and absolute precision as to their relative positions.

This object is attained by maintaining the centre point, around which the cutters revolve, immovably fixed during the process of boring, while the cutters are advanced, and are held in equilibrium with the centre points by a hydraulic medium contained within the chambers of the tool, the pressure being conveyed by the action of the feed given to the boring machine.

This apparatus is exhibited for the purpose of showing how accurate work can be obtained with a minimum of skilled labour and cost.

Machine for drilling Watch Frames.
H.M. Commissioners of Patents.

2076a. Isometric Drawing of an Expanding Mandril, or tool for fixing the tubes in the plates of boilers by expanding the ends so that the tubes are firmly fixed in their places.
W. H. Prosser.

Invented and made by the late Richard Prosser of Birmingham in 1845.

Two of these expanders were sent to the United States in 1847; an improvement on them is now being imported from that country.

2077. Bates' Anaglyptograph. Machine for producing drawings or etchings in relief from models, coins, medals, &c.
George Hogarth Makins.

The machine consists of two portions:—The first a solidly framed oblong base, in which is fixed a long double screw, right-handed at one and left-handed at the other half, and of 20 threads per inch; rotation of this gives opposite motion to two tables, upon the front one of which the object to be copied is fixed, and upon the other the plate to receive the etching or drawing. At the winch end of the screw is fixed a wheel cut with 100 teeth, and also a stop arrangement by which any number of the teeth can be taken, and thus equal partial turns given to the screw.

The second portion of the machine is a framed apparatus carrying the tracing and etching points. This is provided with wheels for travelling across the base, and a groove is formed in the latter for their direction. The tracing point is attached to a bar which in rising does so at an angle of 45°. In the centre of the bar is a piece which, being between friction wheels attached to the diamond or etching point frame, will, as the bar rises by passing over any elevation in the object, cause the diamond frame to move at right angles to the motion of the machine, and thus the line forming is curved or waved just in proportion to the height of the elevation passed over; hence the appearance of relief given to the etching.

2078. Model of a **Steam-boiler** to show Herschel's boiler arrangement. *Bock and Handrick, Dresden.*

2079. Model of **Valve Motion,** to show the link motion of Stephenson, Gooch, and Allan. *Bock and Handrick, Dresden.*

Model of Reversing Gear. *Bock and Handrick, Dresden.*

2080. Drawing of a **Model** for **testing** the **Link Motions** of Stephenson, Gooch, and Allan, for locomotive manufactories. Greatly improved and quite new construction.
Bock and Handrick, Dresden.

2081. Model, for the demonstration of **Centroids.**
Bock and Handrick, Dresden.

2082. Model of a **higher pair** of **Elements.**
Bock and Handrick, Dresden.

2083. Vierkurbelkette. (Four crank-chains.)
Bock and Handrick, Dresden.

2083a. Slider Crank Chain.
Bock and Handrick, Dresden.

2083b. Mechanism of Slider Crank Chain.
Bock and Handrick, Dresden.

2084. Model of a **Hanger.** *Bock and Handrick, Dresden.*

2085. Model of a **Wall Bracket.**
Bock and Handrick, Dresden.

2086. Model of a **Plummer-block.**
Bock and Handrick, Dresden.

2087. Three Models of **connecting Rod-ends.**
Bock and Handrick, Dresden.

2088. Two Models of **rivetted Joints** for **Boiler Plates,** to take to pieces. *Bock and Handrick, Dresden.*

2089. Model of a **Double-beat Valve.**
Bock and Handrick, Dresden.

2090. Model of a **Throttle Valve.**
Bock and Handrick, Dresden.

2091. Model of a **Cup Valve.**
Bock and Handrick, Dresden.

2094. Drawing Instruments and Scales.
Bock and Handrick, Dresden.

2095. Tachometer with registering apparatus, after Dr. Pröll. *Bock and Handrick, Dresden.*

Wood Model of Clutch Gear. *Jeremiah Head.*

2095a. Printing Machinery. This model of an ordinary printing machine illustrates the inventions of Edward Cowper in 1818, and Augustus Applegath in 1823, as applied to the printing of books, newspapers, &c., which had up to that time been commonly printed at hand presses.

The distribution of the ink transversely as well as longitudinally removed the difficulties previously felt, and gave perfect distribution, and consequently good printing. *Edward Alfred Cowper.*

2096. Model of Cowper's Cylinder Printing Machine.
The Council of King's College, London.

2058. First Type-composing Machine, invented by Alexander Mackie.
John Maclauchlan, Dundee Free Library and Museum.

Mr. Mackie's Type-composing Machine, of which this is the germ, is used in offices of some of the London daily newspapers, and various books have been printed by its aid.

2058a. Type composing Machine. *John Walter, M.P.*

2058b. Type casting Machine, distribution being dispensed with. *John Walter, M.P.*

2097. Model of Revolving Screw, with Apparatus illustrative of the Inclined Plane. *The Council of King's College, London.*

2099. Working Model of a patent silk throwing machine. Thomas Dickens, Edgemoor House, Higher Broughton, Manchester. *South Kensington Museum.*

The bobbin, flyer, and reel are driven by friction gear, which secures steady and certain action.

2100. Working Model of a strand-making machine for machine cotton rope; with a 49 reel frame for cotton yarn. Henry Cotton. *South Kensington Museum.*

2101. Model, on a ⅓rd size, of a pirn winding machine. For making weaver's bobbins from cotton hanks. Robert Hall, Hope Foundry, Bury. *South Kensington Museum.*

2102. Model, on a ⅓rd size, of a drum winding machine. For making warper's bobbins from cotton hanks. Robert Hall, Hope Foundry, Bury. *South Kensington Museum.*

2104. Model of power weaving loom by George White, Glasgow, 1830. *South Kensington Museum.*

The shuttle in this loom is arranged with a peculiar even power movement, by which, for the propulsion of the shuttle, one uniform power is exerted, thereby enabling fine fabrics, such as cambrics, lawns, faconets, &c., to be manufactured.

2105. Model of a power weaving loom, showing arrangement for working a double shuttle-box, and other features. Designed about 1840. *South Kensington Museum.*

2106. Model of power weaving loom, with Jacquard arrangement attached, for weaving or working figured stuffs or pattern stuffs. *South Kensington Museum.*

This model shows the arrangement of the cards in the loom after they have been cut for the desired pattern to be worked. It further illustrates the general movement of the several parts of a Jacquard loom.

2106a. Model of **Power Loom** constructed to show the ordinary manner of working the Beam and Taylor's patent method of performing the same. *H.M. Commissioners of Patents.*

2106b. Improved Jacquard Apparatus and **Fittings,** worked by pegs. *Bennet Woodcroft, F.R.S.*

In this improved Jacquard apparatus, those warp threads which are not raised to form the shed or opening for the shuttle to pass through and deposit a weft thread are depressed to the same extent that the others are raised. (Woodcroft's Patent, 1838.)

2106c. Full-size **Section Tappet** for **Looms,** for weaving a variety of patterns. *Bennet Woodcroft, F.R.S.*

2106d. Model of **Loom,** with improved tappet plates and Jacquard apparatus. (Woodcroft's Patent, 1838.) *Bennet Woodcroft, F.R.S.*

2106e. Mule for **Spinning Cotton** and other fibrous substances. (Jas. Smith's Patent, 1833.) *Bennet Woodcroft, F.R.S.*

2106f. Improved Jacquard Machine worked by paper cards. *Bennet Woodcroft, F.R.S.*

The improvement in the jacquard machine consists in its being so constructed and worked as to depress some of the warp threads as much as it elevates others, whereas in the machine invented by Jacquard, and called after him, none of the warp threads were depressed, the opening for the shuttle being made by elevating some of the warp threads only. (B. Woodcroft's Patent, 1838.)

2106g. Steam Power-loom. *Bennet Woodcroft, F.R.S.*

2107. Model of a hand loom, for weaving sacks, hop pockets, &c. This loom is designed to weave sacks or pockets without a seam either at the sides or end. Invented by T. Clulow. *South Kensington Museum.*

2108. Model of a hand loom for weaving fishing nets. G. Roberts, inventor. *South Kensington Museum.*

2109. Model, on a ⅓rd scale, of a plain and fancy goods weaving loom, having 12-inch reed space. The model can be driven either by hand or power. Robert Hall, Bury, Lancashire. *South Kensington Museum.*

2110. Model, on ⅓rd scale, of a plain and fancy goods weaving loom, having 12-inch reed space. The model is arranged to be driven by power. Savill and Woolstenhulme, machine makers, Oldham. *South Kensington Museum.*

2111. Series of Temples (20 in number), of various sizes. Used in power looms for stretching the woven cloth. The temples are self-acting, and are suitable for woollen, cotton, and other heavy or light fabrics. R. Hall, Hope Foundry, Bury, Lancashire. *South Kensington Museum.*

2112. Drawing of patent machinery for preparing chemically pulp from wood, straw, and fibrous material for the manufacture of paper of all kinds and qualities. Sinclair's system. J. McNicol, C.E., 97, Buchanan Street, Glasgow. *South Kensington Museum.*

The drawing represents the following portions of the patent machinery by W. Sinclair, for paper manufacture.

On a ½-inch to 1 foot scale :—

Fig. 1. Longitudinal through section of Sinclair's patent high-pressure tubular steam boiler.

Fig. 2. Front or firing end elevation of Sinclair's high-pressure tubular steam boiler.

Fig. 3. Sectional elevation of wood-pulp boiler.

Fig. 4. End elevation of blow-off pulp receiving tank.

Fig. 5. General plan of apparatus.

Fig. 6. Front and side elevation of wood-chopping machine.

Fig. 7. On a scale of $\frac{1}{4}$ inch to 1 foot. The soda ash (used to dissolve the wood into pulp) recovery apparatus. A longitudinal and cross section of the apparatus.

Fig. 8. On a full size scale. The Sinclair's patent conical plug joint for high-pressure steam boiler tubes.

Fig. 9. On a full size scale. The section of a hollow conical boiler tube joint. Sinclair's system.

2114. Working Drawing, on a $\frac{1}{3}$ scale, or 4 inches to 1 foot.
Sheave or pulley. For a hoisting crane.
Side and end elevations.
Two through sections. *South Kensington Museum.*

2115. Working Drawing, on a $\frac{1}{2}$ size scale, or 6 inches to 1 foot.
Spur wheel. Tooth wheel for gearing.
Side elevation, showing method of laying out pitch of tooth and tooth circle.
Section of arm of wheel.
Section through centre of wheel.
Plan of wheel. *South Kensington Museum.*

2116. Working Drawing, on a $\frac{1}{3}$ scale, or 4 inches to 1 foot.
Mitre wheel, gear wheel. Showing plan, elevation, and sections of wheel. *South Kensington Museum.*

2117. Working Drawing, on $\frac{1}{12}$ scale, or 1 inch to 1 foot.
Eight feet cast-iron fly-wheel.
Side elevation with part of rim in section.
End elevation. Three through sections.
South Kensington Museum.

The wheel is cast in two segments, and united by wrought-iron hoops, shrunk on the boss, and by dowels and cotters at the rim.

2118. Working Drawing, on a $\frac{1}{4}$ scale, or 3 inches to 1 foot.
Cast-iron engine crank.
Side elevation. Plan throughout.
Plan when turned $\frac{1}{4}$ of a revolution.
Section through firm and web.
Longitudinal section, and a section when turned $\frac{1}{4}$ of a revolution. *South Kensington Museum.*

2119. Working Drawing, on a $\frac{1}{3}$ scale, or 4 inches to 1 foot.
Connecting rod end, for a 25 horse-power steam engine.
Elevation. Plan. Two sections.
South Kensington Museum.

2120. Working Drawing, of the governor of a steam engine.
Front and side elevation.
Elevation and plan of slide.

Pendulum rod, showing ball in section, and method of attachment.

Elevation and plan of forked rod.

Section through slide.

The front and side elevations are on $\frac{1}{4}$ scale, or 3 inches to 1 foot.

The details are on $\frac{1}{2}$ scale, or 6 inches to 1 foot.

South Kensington Museum.

2121. Working Drawing, on a $\frac{1}{2}$ scale, or 6 inches to 1 foot.

Pillar block, plummer block, or pedestal; for a $4\frac{1}{2}$-inch shaft or journal.

Side elevation.

End elevation. Plan. Sheet No. 1.

South Kensington Museum.

2122. Working Drawing, on a $\frac{1}{2}$ scale, or 6 inches to 1 foot.

Pillar or plummer block for a $4\frac{1}{4}$-inch shaft or journal.

Various sections. Sheet 2. *South Kensington Museum.*

2123. Working Drawing, on a $\frac{1}{4}$ scale, or 3 inches to 1 foot.

Hanging bracket and pillar block, for a $3\frac{1}{2}$-inch shaft; attached to a 16-inch cast-iron girder.

Front and side elevations. *South Kensington Museum.*

2124. Working Drawing, full size. Steam whistle.

Elevation. Plan. Sections.

The vertical section shows by arrows the passage of the steam through the whistle. *South Kensington Museum.*

2125. Working Drawing, on a $\frac{1}{4}$ scale, or 3 inches to 1 foot.

Movable head stock for a turning lathe.

Side elevation, plan, and section.

End elevation and section. *South Kensington Museum.*

2126. Working Drawing, full size.

Water cock or tap.

Side elevation. End elevation.

Plan. Side and end elevation of plug.

Through section of tap. *South Kensington Museum.*

2127. Working Drawing, on a $\frac{2}{3}$ scale, or 8 inches to 1 foot.

Stop-cock or straightway cock, for steam or water.

End elevation. Side elevation. Plan. Two sections.

Fourteen working drawings (lithographs), parts of machinery and steam engines. Thomas Busbridge, Plumstead, S.E.

South Kensington Museum.

2178gg. Bobbin Winding Machine, by the late Sir Marc Isambard Brunel, 1830. *Maudslay, Sons, and Field.*

2827ff. Original Micrometer Screw Gauging Machine, by the late Henry Maudslay, 1805. *Maudslay, Sons, & Field.*

Each division on the milled head of micrometer screw shows $\frac{1}{10000}$ of an inch.

2127a. Machine for Originating Screws, with micrometer adjustment applied to tangent screw which sets the guide at any angle suitable to required pitch (adjustable to $\frac{1}{100}$ degree). The cutter is carried in sliding rest. Specimens of screws originated in machine. *Maudslay, Sons, and Field.*

2127aa. Machine for Originating Screws of any required pitch and diameter (by the late Mr. Henry Maudslay). *Maudslay, Sons, and Field.*

Inside the cylindrical hole (below the table) is a steel knife edge which is attached to the divided circle (above). This circle and knife edge can be adjusted by a micrometer tangent screw to the calculated angle of the thread. The knife edge presses on and acts as a guide to a cylindrical rod passed through the hole, and gives the required feed while the thread is cut by a small tool carried in the slide rest seen at the side of the machine. The bar on which the screw is to be cut is carried in the centres of a lathe, while the screw machine is allowed to travel freely along the bed of the lathe. The bar is removed from the machine so as to enable the knife edge inside to be seen. When the circle and knife edge are set at the required angle they can be clamped to the frame. Date 1800–1805.

2127b. Three Guide Screws originated in the above machine; each screw contains 50 threads to the inch. The largest screw is $1\frac{11}{32}$ in. diameter and has 3,144 threads in the entire length. The nut for this screw is shown by its side; it is 12 inches long and has 600 threads. *Maudslay, Sons, and Field.*

2127c. Hand Plane for Metal, by the late Mr. Henry Maudslay. *Maudslay, Sons, and Field.*

2127d. Metal Plough for Moulding, by the late Henry Maudslay. *Maudslay, Sons, and Field.*

2127f. Original Screw Cutting Lathe, made and used by the late Henry Maudslay. It has 28 change wheels, and sector frame for carrying an intermediate wheel for cutting left hand screws. Four guide screws are shown, 100 threads, 50 threads, 35 threads, 30 threads to the inch. Also a small cone chuck and hollow mandril, screw tools for slide rest, and the original working handle used by Mr. Maudslay, below the bed. Date 1800 to 1810. *Maudslay, Sons, and Field.*

2127g. Skeleton Stocks and Dies, four sets, about 1805 to 1810, made and used by the late Henry Maudslay. The extreme delicacy and finish of the work are worthy of notice. *Maudslay, Sons, and Field.*

2127h. Coining Machinery. A cutting-out press for blanks, with self-acting feed rolls to deliver fillet. Date about 1814.
Maudslay, Sons, and Field.

297a. Micrometer Gauge and Screw, unfinished; divisions adjusted to show $\frac{1}{10000}$th of an inch.
Maudslay, Sons, and Field.

297b. Micrometer (Screw) Gauging Machine, by the late Mr. Henry Maudslay, divided on the head of micrometer screw to show $\frac{1}{10000}$th of an inch. *Maudslay, Sons, and Field.*

2178go. Drawing of Machinery for Boring Cannon, for Rio Janeiro, 1813. *Maudslay, Sons, and Field.*

2135. Three Elliptical Guides.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2138. Elliptic Guide, with long radius bar.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2139. Approximate Elliptic Guide.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2142. Kinematic Pillar Vice, with triangular link-motion.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

This stand is so arranged that any link of the kinematic chains can be fastened in it easily and securely, so that they can be shown in every possible position.

WHEEL GEARING.

2140. Spur Wheel Gearing.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2143a. Model of a Machine for Cutting the Teeth of Bevel Wheels. *F. Engel, Hamburg.*

In the usual cutting and planing machines for bevel wheels, each space between the teeth is produced by at least two operations; first one side of a tooth is shaped or planed, then the opposite side of the next tooth. The present machine cuts both profiles simultaneously with the same cutter. A lateral motion is communicated to the cutter, the axis of the tool oscillating about the cutting point of the conical surface, and working alternately the one and the other side of the tooth profile, while the feed of the tool is self-acting. The machine is more accurate than previous ones, and other kinds of wheel can be shaped with it.

2143b. Samples of Wheels which have been cut by the Machine. *F. Engel, Hamburg.*

2143c. Drawing of the Machine. *F. Engel, Hamburg.*

2144. Bevel-Wheel Gearing.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

The models exhibited are a small portion of the collection used for machine-instruction in the Königlichen Berg-Akademie (Royal School of Mines). They have been made specially for this purpose by Herr Maiss, in the workshops of the Academy, upon the designs of Prof. Hörmann. The models of separate mechanisms have been constructed upon the principles laid down in Prof. Reuleaux's "Theoretische Kinematik"; they are all arranged for "inversion," that is, so that either of their links may be fixed in the screw stand exhibited with them, and the various properties and applications of the inversions easily shown.

The models are all made with the special view of illustrating in the most complete, clear, and simple manner the principles of the machines and mechanisms which they represent. All details not required in this relation are omitted or made subordinate, the parts which it is important for the students to observe are polished, the other parts, in order not to attract attention unnecessarily, are made a dead black, so that all disturbing reflections of the light are prevented. Care has been taken also to arrange them so that all essential parts and their combinations may be visible at a glance in all parts of the class-room, so that the alterations which it is necessary to make during the lectures may occupy a minimum of time, and altogether that teachers may find their use in demonstrations very convenient. In the steam-engine models have been made, the relative dimensions and arrangements, as far as possible, to resemble those of actual practice.

2144a. Pair of Worm-Wheels, with parallel axes.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144b. Worm-Wheel, with inclined teeth.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144c. Annular Wheel and Pinion.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144d. Hypocycloidal Gearing.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144e. Worm-Wheel, with straight teeth.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144f. Pair of Worm-Wheels, with axes at right angles.
Royal Geological Institute and Mining Academy (Director, Prof. Hauchecorne), Berlin.

2144g. Skew Mitres.
The Committee, Royal Museum, Peel Park, Salford.

A pair of toothed mitre wheels mounted on shafts that cross each other. The invention of the late R. Roberts, C.E., of Manchester, 1836.

2144h. Intermittent Wheels.
The Committee, Royal Museum, Peel Park, Salford.

The larger wheel performs six revolutions for one of the lesser. The invention of the late R. Roberts, C.E., of Manchester.

2145. Model of Cugnot's Steam Carriage, 1783.
Conservatoire des Arts et Métiers, Paris.

2146. Model of a centrifugal smoke purifier.
Dr. Otto Braun, Berlin.

This model shows the action of centrifugal force on bodies suspended in gases, by means of it sparks, soot, tar, ammonia, &c. can be removed from smoke.

2146a. Tyndall's Smoke Filter Respirator, suitable for firemen, fire-escape men, and for persons entering deleterious atmospheres. *James Sinclair.*

The filtration is by means of layers of dry cotton wool, cotton wool dipped in glycerine, and charcoal.

2146b. Tyndall's Smoke Filter Respirator, combined with elastic tube, suitable for mining operations, chemical works, breweries, &c. *James Sinclair.*

This respirator is designed to enable the wearer to enter and breathe freely in mephitic gases by means of the tube, which can be used in lengths up to 90 feet, the wearer being enabled to communicate verbally with those outside and they with him.

1925. Chinese Steel Helmets (2).
Bennet Woodcroft, F.R.S.

1926. Chinese Cane Helmets (2).
Bennet Woodcroft, F.R.S.

IX.—SHIPPING, NAVAL ARCHITECTURE, AND MARINE ENGINEERING.

2147. Models made of hard paraffin for ascertaining the **Resistance** of **Ships** by measuring the resistance of their models.
W. Froude, F.R.S.

The models, from 6 to 16 feet in length, and from 120 lbs. to 700 lbs. displacement, are made of hard paraffin. The experimental apparatus employed in the treatment of the models includes appliances for designing, moulding, and casting them, shaping them by automatic machinery, moving them through the water at the required speeds, and automatically recording the leading phenomena of the trial, namely, the speed, the resistance, and the change of level induced by the speed at each end of the model.

The several processes are illustrated by the accompanying series of seven photographs and two specimens, which may be explained as follows:—

No. 1. The designer.

This consists of a pile of adjustable templates, the thicknesses of which represent the horizontal intervals between the successive water-lines of the intended models, shown on a reduced scale. One edge of each template is an elastic steel band held to a wooden base-piece by adjustable ordinates hinged to the band and sliding through mortices in the base-piece fitted with hinged metal clamps. One of these templates (No. 8) set up as for use is sent to aid this explanation.

The photograph shows them in combination; when thus placed they represent the intended model on a reduced scale, by a series of water-lines in steps, which, if either filled up solid and fair to the salient angle of each, or trimmed off fair to the re-entering angle, would constitute the finished form.

No. 2. The moulding box, the mould, and the core.

The former is a rectangular wooden box $\overset{\text{L.}}{16'} \times \overset{\text{B.}}{2'\,9''} \times \overset{\text{D.}}{1'\,10''}$. containing plastic clay.

In the clay the external form of the full sized model is moulded by help of a series of rough cross sections deduced from the small scale designer, and into the mould is fitted the core, which constitutes the figure of the inside of the model. The core is framed on a series of internal cross sections made good to a surface and rendered coherent, first by a series of laths nailed to them externally, and, secondly, by a skin of calico drawn tight over the lathed surface, and then coated with plaster-of-paris and clay. Between this "core" and the "mould" there is, of course, a space, equal to the intended thickness of the model, into which space the melted paraffin is run, and there allowed to remain until by cooling it has become solid enough to bear removal.

Nos. 3 and 4, the shaping machine.

This is what has sometimes been termed in technical phrase a "copying machine." The model, bottom upwards, and adjusted successively to a series of different levels, travels longitudinally between a pair of revolving cutters, which are caused by means of a hand lever to so recede and approach one another, as the model passes, as to cut upon the model the horizontal section or "water-line," correctly appropriate to the level at which the model is set. At the side of the machine, in full view of the operator, there is a vertical board, which carries either a drawing of the intended model, showing the series of water-lines to be cut, or one of the "designer" templates already described. In front of this board is a "tracer," and the board and the "tracer" severally imitate upon the appropriate scales (the former by longitudinal motion, the latter by vertical motion) the longitudinal motion of the model and the lateral motion of the cutters. Thus the drawing (or template) passing along beneath the tracer, is practically a small scale picture of the model travelling past the cutters, and if the tracer be made to follow the correct line on the drawing (or to follow the edge of the template) the revolving cutters will cut the correct water-line on the model.

The model is then finished by hand with spokeshaves and scrapers, an operation which takes a man about three hours.

No. 5. The hauling engine.

This is the instrument by which the required motion through the water at definite speed is given to the model. The dynamometric truck to which the model is attached, is connected by a wire rope with a winding drum, driven by a small stationary double-cylinder steam engine. The engine is regulated by an extremely sensitive governor, acting upon a delicate steam throttle valve, on what is known as the "differential" principle, in which the governor rotates at its own appropriate speed, independently of the engine, the steam valve being opened or closed according as the engine is lagging behind the governor or overtaking it.

By adjusting the centrifugal weights of the governor, with a right and left-handed screw, and by differently speeding the belt which connects it with the engine, any required speed may be assigned to the engine between the limits of about 150 and 350 revolutions per minute, and by further changing the gear wheels connecting the engine and winding drum, speeds varying from 60 to 1,200 feet per minute may be assigned to the dynamometric truck.

Nos. 6 and 7. The dynamometric truck with model under it.

The dynamometric truck runs on a straight and level railway about 200 feet in length, suspended over a waterway 36 feet wide and 10 feet deep roofed throughout. The model floating in the water is as it were "harnessed" to the truck, and travels with it. It is kept from diverging sideways by a knee-jointed frame or "guider" at each end, of such construction as to perfectly prevent the slightest sideways deviation of the model, but in no way to interfere with its rising or falling, or moving in a fore and aft direction with reference to the truck. The towing strain (*i.e.*, the force necessary to make the model accompany the truck in its longitudinal progress) is taken during the experiment by a spiral spring, the extension of which, measuring the towing force, is indicated on a large scale (through the intervention of certain levers) by a pen which makes a line on a recording cylinder covered with a sheet of paper. The recording cylinder is driven by the truck wheels, and thus its circumferential travel indicates distance run; at the same time another pen, jerked at half second intervals by a clock, records time. Other pens actuated by strings led over pulleys, record the change of level of the ends of the model. Thus the diagrams made furnish an exact measure of the speed, and a continuous record of the resistances and of the change of level of the model throughout the experimental run at steady speed. While starting or stopping, the model is controlled by hand levers to prevent the dynamometric spring being overstrained.

No. 8. A "designer" template.

This consists of one of the pile of adjustable templates shown in photograph No. 1, and already described.

No. 9. A segment of a model.

This specimen segment of a model is partly in a finished condition and partly in the condition in which it is left by the shaping machine, Nos. 3 and 4. It thus shows the series of water-line cuts made by the machine, and a part of the original cast surface remaining between the cuts.

2147aa. Model of the solid of **"Least Resistance,"** by the late Andrew John Robertson, dated 1861. *Michael Scott.*

2147ab. Model of the Steam Ship **"Sir John Lawrence,"** embodying to a considerable extent the form of least resistance, designed by Michael Scott, in conjunction with the late Andrew John Robertson. The performance of this ship was excellent.
Michael Scott.

2147ac. Three diagrams of a new type of **War Ship,** designed by Michael Scott in 1869, and published in 1870.
Michael Scott.

In this design the surface exposed to hostile fire is diminished by constructing the vessel with a central fort, armour plated all round, an armoured deck under water, and dividing the space above this armoured deck for a height of six feet into water-tight compartments, which would be filled with fuel or water when going into action. She is intended to carry both turret and broadside guns, and might be armed with a submarine gun.

2147ad. Three diagrams of new type of **War Ship,** designed by Michael Scott in 1870, and published in 1871.

Michael Scott.

In this design there is a central fort, armour plated all round; an armoured deck under water sloping downwards towards the bow, so as to prevent the vessel from being raked in a seaway, and strengthening the ramming stem. The ship is intended to carry sail, to be dismantled before going into action, her turrets to be placed abreast, and also to carry broadside guns.

Some of the most important features in these designs have been adopted in the most modern war ships.

2150. Parent Steam Engine, made for Patrick Miller, Esq., and used by him on the lake at Dalswinton, 1788.

Bennet Woodcroft, F.R.S.

For some years prior to 1787 Patrick Miller, Esq., of Dalswinton, Scotland, had been engaged in a series of experiments with double and triple vessels propelled by paddle-wheels, worked by manual labour. In the experimental trips of 1786 and 1787 he was assisted by Mr. James Taylor (the tutor to his younger sons), and at the suggestion of the latter it was determined to substitute steam power for manual labour. For this purpose, in the early part of 1788, Taylor introduced William Symington, an engineer at Wanlockhead Lead Mines, who had previously obtained letters patent (June 5, 1787, No. 1,610) for "his new invented steam engine on principles 'entirely new.'"

An arrangement was made with Symington to apply an engine, constructed according to his invention, to one of Mr. Miller's vessels, and consequently the engine which forms the subject of this notice was made, the castings being executed in brass by George Watt, founder, of Low Calton, Edinburgh, in 1788. At the beginning of October in that year the engine, mounted in a frame, was placed upon the deck of a double pleasure boat, 25 ft. long by 7 ft., and connected with two paddle-wheels, one forward and the other abaft the engine, in the space between the two hulls of the double boat. On the steam being put in action it propelled the vessel along Dalswinton Lake at the rate of 5 miles an hour.

2178bc. Original Whole Model of the Steam Boat "Comet." Built on the Clyde by J. Wood for Mr. Henry Bell, at Port Glasgow, 1811. Length 42 ft., breadth 11 ft., depth 5 ft. 6 ins.

John Reid and Co.

In August 1812, the steam passage boat "Comet," being the first steam vessel ever built in Europe, began to run between Glasgow, Greenock, and Helensburgh, with passengers only. She was advertised to leave the Broomielaw on Tuesdays, Thursdays, and Saturdays, at an hour suitable to the tide, and to return from Greenock on Mondays, Wednesdays, and Fridays. The fares were 4*s.* for the best cabin, and 3*s.* for the second, and no gratuities to the vessel's servants were allowed. The boat was driven by a condensing steam-engine of 4 horse-power. She had at first two sets of paddle-wheels on each side of the vessel (shown in the model). Her greatest speed was five miles per hour.

2178cb. Working Drawing, by John Wood, Port Glasgow, of the "Comet," built by him in 1811 for Henry Bell.

R. Napier.

The "Comet" was the first vessel propelled by steam that regularly traded in Europe.

This drawing was presented by John Wood to R. Napier.

The *engine* of this vessel was presented by R. Napier and Sons to the South Kensington Museum.

2178ct. Photograph of the "Comet" and "Iona" Steamers, 1811, 1874. *John Hamilton.*

From a painting by Wm. Clark-Greenock, to illustrate and keep on record the appearance of the first British steamer, and also to make a comparison between the past and present types of Clyde river steamers.

2148a. The **Original Engine** of **Henry Bell's Steamboat "Comet,"** which was the first steamboat in Europe advertised for the conveyance of passengers and goods.

H.M. Commissioners of Patents.

The engine was made and fitted on board the "Comet" in 1812.

2148b. Drawing of the "Elizabeth," built by Charles Baird in 1815, and run on the Neva.

George Baird, St. Petersburg.

She was constructed out of a barge, and the chimney was of brick. The floats of the paddle-wheels were kept in a vertical position by means of shafts and mitre wheels. Scale of drawing, $\frac{1}{4}$ inch to the foot.

2148c. Drawing of Paddle-wheel Steamer, built by Charles Baird in 1817, to carry passengers between Petersburg and Cronstadt, showing end view, longitudinal view, plan, and longitudinal section. *George Baird, St. Petersburg.*

A. Steam engine.
B. Boiler.
C. C. Crank shafts on either side, with fly-wheel.
D. D. Toothed wheels driving paddle-wheels.
E. E. Paddle-wheels with floats revolving 50 turns per minute, by which the vessel is propelled.
F. Funnel leading from furnace serving in place of a mast.
G. G. Fore and aft cabins.
H. H. Side decks, to protect the wheels from the blows of the waves.
I. I. Paddle-boxes.
K. L. Staircase and rudder.
Scale of drawing, $\frac{1}{4}''$ to 1 foot.

2148f. Picture of the "Great Western" steamship, the first steamer that traded regularly between England and America. Date 1838. *Maudslay, Sons, and Field, Engineers.*

2148g. Table of the first 50 Voyages of the "Great Western" steamship.
Maudslay, Sons, and Field, Engineers.

2175. Models (3) of **Varying-pitch Screw Propellers.** Woodcroft's Patent, 1838. *Bennet Woodcroft, F.R.S.*

2176. Varying-pitch Screw Propeller on shaft.
Bennet Woodcroft, F.R.S.

2177. Skeleton Model of part of a **Vessel** fitted with a **Screw Propeller.** (Cummeron's Patent, 1828.)
Bennet Woodcroft, F.R.S.

2178. Model of **Vessel** fitted with **Screw Propeller,** by Sir Francis Pettit Smith. *Bennet Woodcroft, F.R.S.*

The propeller consists of two whole turns of a screw thread round its shaft, and is placed in the dead wood or run of the vessel, but by a memorandum of alteration the patentee limits himself to a screw of one turn or two half turns.

2180e. Memoir, written by Don Fernandez Duro, upon the models of metal plated ships made in the last century, preserved at the Ministry of Marine at Madrid. With plates.
Archæological Museum, Madrid.

2149a. Drawing of Steam Vessel, by the exhibitor.
The late Baron Séguier, Membre de l'Institut.

EXHIBITED BY THE SOUTH KENSINGTON MUSEUM.

2178fk. Model of the **After Body,** showing complete framing, of the Screw Steamer **"Novelty."** Built 1839–40. Mr. H. Wimshurst. *South Kensington Museum.*

This vessel was the first fitted with direct-acting engines to drive the screw, and having means also of shipping and unshipping the propeller.

2155. Model, on a $\frac{1}{10}$ scale, of the **Horizontal Condensing Screw Engines of H.M. Ships** "Nelson," built 1814, altered for the screw propeller 1860; "Conqueror," built 1833, altered for the screw propeller 1859; and "Tamar," built 1863. The engines are of 500 horse-power, nominal. Diameter of cylinders, 71 inches; stroke, 3 feet. Ravenhill, Easton, and Co., Engineers, Ratcliff, London. *South Kensington Museum.*

2160. Model of the **Engines of the Paddle-wheel Steamer "Helen McGregor,"** of Liverpool.
Designed in 1843 by G. Forrester & Co., Engineers.
South Kensington Museum.

This engine has two inverted steam cylinders of very long stroke, driving one crank on the paddle shaft. It is a condensing low-pressure engine, it occupies but little hull space, and is said to be still at work, 1873.

2161. Model of a **Paddle Marine Engine,** designed by J. Scott Russell, F.R.S.; having three oscillating cylinders, all connected to one crank on the paddle shaft. One of the cylinders is vertical, the other two are inclined inwards at about 45°. J. Scott Russell, F.R.S. *South Kensington Museum.*

2152. Model, on a scale of $1\frac{1}{2}$ inches to 1 foot, of the **Horizontal Condensing Screw Engines of H.M. Turret Ship "Monarch,"** 8,164 tons. Built, 1868. 1,100 horse-power, nominal. Lent by Humphrys and Tennant, Engineers, Deptford. *South Kensington Museum.*

The engines of H.M.S. "Monarch" are of 6,600 indicated horse-power, and were designed and built in 1868 by the lenders of the model. The engines make 60 revolutions per minute, and are on the direct-acting principle, with return connecting rods, and have surface condensers. There are four piston rods to each engine piston. The cylinders are 120 inches in diameter, having a stroke of 4 feet 6 inches.

The condensers are of wrought iron, their tops being of cast brass. They can be used either as surface or jet condensers. They contain 17,264 copper tubes, each 6 feet long, giving large condensing surface per nominal horse-power. The water is driven through the condensers passing outside the tubes, by a reciprocating pump, the inlet and outlet pipes being of ample diameter.

The cylinders of the engines are steam jacketed.

The crank shaft is 22 inches in diameter, and the propeller shaft 18 inches.

The starting, stopping, and reversing gear is placed on a central platform between the cylinders and condensers of the engines.

The crossheads to piston rods are forged solid; their guides have very large surfaces, and are easily adjusted.

The boilers are tubular, having brass tubes. They contain 21,000 square feet of heating surface, and about 770 square feet of grate surface.

The ship's propeller is a two-bladed Griffith screw, of gun-metal; 23 feet 6 inches diameter, with adjustable pitch from 23 feet 6 inches to 28 feet 6 inches, weighing 22 tons.

2153. Model, on a scale of 1 inch to 1 foot, of the **Horizontal Condensing Screw Engines of H.M. Turret Ship "Prince Albert,"** 2,529 tons. Built 1860. 500 horse-power, nominal. Humphrys and Tennant, Engineers, Deptford. *South Kensington Museum.*

The "Prince Albert" was built in 1864 by Messrs. Samuda. She is an armour-plated turret ship, 240 ft. in length, 48 ft. beam, 25 ft. 3 inches in depth. She is driven by engines, of which the model is a representation, and fitted with a four-bladed screw propeller.

2178fa. Whole Model of the Cunard iron paddle steamer **"Scotia."** Built 1861. Constructed for the British and North American (Cunard) Royal Mail Steam Packet Company, by R. Napier & Sons, Glasgow. Length 366 ft., breadth 47 ft. 6 in.; tonnage, builder's measurement, 4,050; load displacement, 6,520 tons; horse-power, 1,000 nominal; diameter of cylinders, 100 in.; length of stroke, 12 ft.; diameter of paddle-wheels, 40 ft.; size of floats, 11 feet 6 in. by 2 ft. *South Kensington Museum.*

2178fb. Whole Model of the Woodside ferry paddle steamboat **"Cheshire,"** employed between Birkenhead and Liverpool. Licensed to carry 1,620 passengers. Draught of water 6 ft.—Designed by Mr. George Harrison, M. Inst. C.E.
South Kensington Museum.

2178fc. Whole Model of the screw steamship **"Faraday."** Built by Mitchell & Co., Newcastle, in 10 months, 1874, for Messrs. Siemens Brothers, for employment in carrying and laying electric telegraph cables for ocean telegraph lines.—Dr. C. W. Siemens, Queen Anne's Gate. *South Kensington Museum.*

2178fd. Half Model of the iron sailing ship **"Victory."** Built 1863. Tons 1,198.—Designed and built by Laurence Hill & Co., Glasgow. *South Kensington Museum.*

2178fe. Half Block Model of the Royal Mail screw steamship **"Boyne."** Built 1871. Length (keel) 358 ft. 6 in., breadth 40 ft. 5 in., depth 34 ft. 6 in.; tons o.m. 2,882.—W. Denny and Brothers, Dumbarton. *South Kensington Museum.*

2178ff. Half Model of paddle steamer **"Glengyle."** Constructed for the navigation of the river Yangtzee. Tons 2,040; horse-power, 400 nominal.—W. Denny and Brothers, Dumbarton, N.B. *South Kensington Museum.*

2178fg. Half Model of a corvette of the **"Alabama"** class. Proposed by Mr. George Turner, late master shipwright, Woolwich Dockyard.—Mr. George Turner.
South Kensington Museum.

2178fi. Whole Model of H.M. Indian relief steam troopship **"Jumna."** Built 1866, by Palmer's Shipbuilding Company. Length 365 feet, breadth 48 ft. 9 in., depth 42 ft.; tons gross, 4,174; horse-power, 700 nominal; speed, 14½ knots per hour; scale, $\frac{1}{48}$th real size.—Palmer's Shipbuilding Company, Limited, Newcastle-on-Tyne. *South Kensington Museum.*

2178fj. Whole Model of the Mail Screw Steamer **"Montana,"** Liverpool and New York line. Built 1873, by the Palmer's Shipbuilding Company, Limited. Length 412 ft., breadth 43½ ft., depth 42¾ ft.; tonnage gross, 4,320 horse-power, nominal, 900; speed, 15½ knots per hour; scale, $\frac{1}{48}$th full size.—The Palmer Shipbuilding Company, Limited, Newcastle-on-Tyne.
South Kensington Museum.

2154a. Model, showing the complete **Framing** and **Construction** of the after body of the second **"Submerged Propeller,"** or screw steamship "Novelty," built by Mr. H. Wimshurst, 1839–40. *South Kensington Museum.*

This was the first vessel fitted with direct-acting engines to drive the screw propeller, and having means for shipping or unshipping the same.

2156. Model (working), on a 3 inch to 1 foot scale, of the **Condensing Vertical Screw Engines** of steamship "A. Lopez," Cadiz and Havannah Spanish Mail Service.

South Kensington Museum.

The engines are constructed on the hammer or inverted cylinder principle, and have condensers, air and feed pumps, variable expansion gear, &c. The model is a complete working condensing engine of about 15 horse-power. It was made in 1866–7, and exhibited in motion at the Paris Universal Exhibition of 1867. W. Denny and Brothers, Engineers and Shipbuilders, Dumbarton.

The condensers of these engines are on Spencer's surface plan. They comprise a large central box, on the top edges of which rest the cylinders. The piston rods, two to each piston, work down by the sides of the condenser, and move in guides carried by the sides of the box. The pumps are worked off the cross heads, which are suitably prolonged for the purpose.

2158. Drawing, on a 1 inch to 1 foot scale, of the **Compound Inverted Cylinder Screw Engines** of the steamships "Edinburgh Castle" and "Windsor Castle," built and engined in 1872 by the donors of the drawing.—R. Napier and Sons, Engineers, Glasgow. *South Kensington Museum.*

The engines are of 270 horse-power, nominal, having surface condensers, air and feed pumps, link motion for reversing, &c.

Diameter of high-pressure cylinder, 44 inches.

Diameter of low-pressure cylinder, 72 inches.

Stroke, 3 feet 6 inches.

The steamships belong to Messrs. Donald Currie and Co.'s Colonial Line of Mail Steamers, and run direct between London and the Cape of Good Hope.

2159. Model, on a scale of 1½ inch to 1 foot, of the **Oscillating Cylinder Condensing Engines** of the Holyhead and Kingstown Royal Irish Mail **Paddle Steamer "Leinster."** 750 horse-power, nominal. Diameter of cylinders, 98 inches; stroke, 6 feet 6 inches. *South Kensington Museum.*

To the engines are attached, on the same scale, the feathering float paddle-wheels of the ship, which are 32 feet in diameter. The floats are 12 feet long by 4 feet 10 inches deep. Ravenhill, Easton, & Co., Engineers, Ratcliff, London.

The length of the "Leinster" is 350 feet over all. Beam, 35 feet; depth of hold, 21 feet. Tons, 2,000. The ship has 8 boilers, 4 before and 4 abaft the engines, having 40 furnaces fired in line with the keel. The draught of the ship is 8 feet 6 inches on an even keel, and her speed about 21 statute miles per hour. She was built by Messrs. Samuda Brothers, Poplar, in 1860.

2153d. Model of H.M. Steam Troopship "Orontes," on a ¼ scale, showing the arrangement of three canting bridges for lifeboats, with lifeboats built on Lamb and White's principle. Also 10 of Captain J. W. Hurst's patent life-rafts, lashed to ship's side.—J. White, Cowes. *South Kensington Museum.*

2153e. Model of a Surf-boat, for service on West Coast of Africa. Built by Forrest and Son for the War Department, 1872–3. Scale 1 inch to 1 foot; length 25 ft., breadth 5 ft., depth 2 ft. 3 in.—Forrest and Son, Limehouse.
South Kensington Museum.

2153f. Model of Pleasure Boat. Built for Lord Castlerosse in 1861 for the use of Her Majesty during her visit to the Lakes of Killarney.—Searle and Sons, Lambeth.
South Kensington Museum.

2153g. Model of the Lifeboat and its Transporting Carriage, on about a $\frac{1}{10}$ scale; adopted by the Royal National Lifeboat Institution. Length 33 ft., breadth 8 ft., depth inside 3 ft. 4 in. *South Kensington Museum.*

2178fm. Whole Model of the Australian lifeboat **"Lady Daly."** Built at Adelaide, from designs by Mr. W. Taylor, Government shipwright at that port, 1867. Length 43 ft. 1 in., breadth 9 ft., depth midships 4 ft. 1 in.; scale, $\frac{3}{4}$ inch to 1 ft. The model was presented to His Royal Highness the Duke of Edinburgh, by the Marine Board of South Australia in 1868. —H.R.H. The Duke of Edinburgh. *South Kensington Museum.*

2178fl. Whole Model, rigged, of a **Thames Sailing Barge.** Built 1855. Length 70 ft., breadth 16 ft., depth 6 ft.—Searle and Sons, Lambeth. *South Kensington Museum.*

2162. Drawing, coloured, of a **Patent Multi-flue High-pressure Marine Boiler;** by Messrs. R. & W. Hawthorn, 1868. Scale, $\frac{1}{2}$ inch to 1 foot. R. & W. Hawthorn, Engineers, Newcastle-on-Tyne. *South Kensington Museum.*

The drawing shows a front view and cross section of the boiler, longitudinal and cross sections, and a sectional plan.

2163. Model of a set of **Patent High-pressure Marine Tubular Boilers;** designed for the continuous use of fresh water. William Gray, Dawlish. *South Kensington Museum.*

These boilers possess the following arrangements:—They are fired from each end, the furnaces having special air-flues designed to assist in the combustion and the consumption of smoke. They are multi-tubular boilers, having steam superheaters, and over all large tanks to contain fresh water, which supply the boilers with heated feed water. The working pressure is 100 lb. per square inch.

2164. Drawing. Sections of Gray's Patent High-pressure Marine Steam Boilers, showing arrangement of the tubes, steam superheater, water heater, and flues. Scale, $\frac{1}{2}$ inch to 1 foot. W. Gray, Dawlish.
South Kensington Museum.

2165. Drawing, on a $\frac{3}{4}$ inch to 1 foot scale, of an **Improved Marine Tubular Boiler;** for high pressure. Designed and patented by Messrs. J. and F. Howard. Made by the Barrow Shipbuilding Co., Barrow-in-Furness. J. and F. Howard, Engineers, Bedford. *South Kensington Museum.*

The drawing shows a front view of the boiler, side elevation, longitudinal section; and a section through tube plates showing method of coning joints, on a quarter full-size scale.

2166. Drawing of **Messenger's Patent High-pressure Vertical Water-tube Boiler;** for steam yachts and launches. Designed by Thomas Messenger about 1869. A. Verey and Co., Engineers, Dover. *South Kensington Museum.*

2167. Steam Donkey Engine and Pump, single-acting, for feeding steam boilers with water. Alexander Wilson and Co., Engineers, Vauxhall Works, Wandsworth Road, S.W. *South Kensington Museum.*

Diameter of steam cylinder, $3\frac{1}{2}$ inches; stroke, 4 inches. Diameter of pump, $1\frac{7}{8}$ inches. Will pump 460 gallons per hour, and feed a 30 h.p. steam boiler.

2157. High-pressure Non-condensing Screw Engine of 3 horse-power, for screw steam launches. Constructed on the hammer or inverted cylinder principle. Diameter of cylinder, 5 inches. Stroke, 6 inches. A. Verey and Co., Engineers, Dover. *South Kensington Museum.*

2153h. Pencil Drawing, by William Van der Velde, Amsterdam, 1663–1707. Hull of the ship of war "Sovereign of the Seas," 1687.—Mr. G. Smith. *South Kensington Museum.*

2178ehh. Model, Martin's patent self-canting anchors; adopted by the British Government and fitted to H.M. ships "Devastation," "Thunderer," and others.—C. Martin, King William Street, E.C. *South Kensington Museum.*

2180b. Model, in wood, on $\frac{1}{4}$-inch scale of the **"Lowe-Vansittart" screw-propeller blades,** as invented and fitted in 1869 by Mrs. Henrietta Vansittart, for trial on board H.M.S. "Druid," 350 horse-power. *South Kensington Museum.*

2148d. Model of **Screw Propeller,** driven by a pair of engines direct acting, having sun and planet motion, so as to give the propeller two revolutions for every revolution of the engine. *Glasgow Mechanics' Institution.*

2148h. Model of the sailing ship **"Cairnsmore,"** length 223 ft., breadth 33 ft. 6 in., depth 20 ft. 6 in.; tonnage, O.M. 1211. Built by John Reid and Co., Port Glasgow, for Messrs. Nicholson and McGill, Liverpool, 1854. *John Reid and Co.*

This ship made her first passage from Clyde to Bombay in 65 days.

2149. Model of a **Direct-acting Marine Steam Engine.** Patented by J. Miller, A.D. 1841, No. 9,107.
H.M. Commissioners of Patents.

2153a. Whole Model of an Iron Floating Dock, built for the French Government by Messrs. Randolph, Elder, and Co., Glasgow, for Port Saigon, Cochin China. *John Elder and Co.*

Dimensions of the dock:—Length 300 feet, breadth 94 feet, depth 42 feet. Weight of dock, 2,800 tons.

The dock will lift a ship of 4,800 tons weight, drawing 27 feet of water.

2153b. Three Drawings of **Compound Marine Engines,** constructed and fitted on board H.M.S. "Constance" in 1863, by Messrs. Randolph, Elder, and Co., Glasgow. *John Elder and Co.*

They were the first compound engines fitted in any of H.M. ships, and have two 60 inch cylinders, four 78 inch cylinders, of a stroke of 3 feet 3 inches, and are fitted with surface condensers.

No. 1, Plan, looking forward.
No. 2, Cross sectional elevation, looking forward.
No. 3, Cross sectional elevation, looking astern.

2153c. Model of Lifeboat Bridge and **Lifeboat,** as fitted on board H.M.S. "Orontes" and "Tamar," showing the method of carrying and launching ships' life-boats transversely.
John White.

This is a working model of Mr. J. White's plan, adopted by the Admiralty for H.M. ships of war and Indian relief troop ships, for carrying and launching life-boats from ships' upper deck.

2154. Model of Dawes and Holt's Marine Engine.
Henry P. Holt, C.E.

This is of the vertical compound condensing type, without intermediate receiver between high and low pressure cylinders, and very short passages, reverse action of pistons, parallel motion, single crank and connecting rod, one vertical and one horizontal air pump, the former forming a counterbalance to connecting rod, and the latter is arranged to be used as a starting cylinder when required.

2168b. Wave-Indicator. An instrument intended for the direct tracing of the height of the waves, and for deducing their form. *Vice-Admiral Paris, Paris.*

2168c. Rolling-Indicator. An instrument indicating the rolling of ships, not only at its extreme amplitude, but during all its periods. *Vice-Admiral Paris, Paris.*

These two instruments are due to the late Lieutenant Armand Paris, son of the Admiral.

2169. Set of (eight) Models of the Block-making Machinery invented by Sir Isambard Brunel, for the use of

Government, and set up in Portsmouth Dockyard by Messrs. Maudslay and Sons in 1804, where it has remained in use to the present time. *Royal Naval Museum, Greenwich.*

2169a. Model of Wrought-iron Ship's Block, by the exhibitor. *The late Baron Séguier, Membre de l'Institut.*

2170. Plan for Feathering a Screw Propeller, proposed by Messrs. Maudslay, Sons, and Field, 1848.
Royal Naval Museum, Greenwich.

2171. Hirsch's Screw Propeller.
Royal Naval Museum, Greenwich.

2172. Four-bladed or Two-bladed Screw Propeller.
Royal Naval Museum, Greenwich.

2173. Working Model of a pair of **Inverted Cylinders Marine Engine** for driving a screw propeller. Cylinders $2\frac{7}{8}$ inches bore, stroke 4 inches, link motion and reversing gear complete, shut-off valve, &c. Full sized partly shaded drawings of same. Made by exhibitor during his apprenticeship.
Robert Lathbury.

2174. Model in mahogany of a **Three-bladed Griffiths' Patent Screw Propeller.** Made by exhibitor during his apprenticeship. *Robert Lathbury.*

2178dn. Model of Small Steamer "Mab," the fastest on the Neva. Built in 1874, of brass, by George Baird, St. Petersburg.

Length - - - -	48 ft.
Breadth - - - - -	6 ft. 6 in.
Depth at side - - -	3 ,, 6 ,,
Draught - - - -	1 ,, 7 ,,
,, over screw - - -	2 ,, 9 ,,
Speed - - - -	19 miles.
Diameter of high pressure cylinder -	7 ins.
,, low ,, -	11 ,,
Stroke - - -	8 ,,
Working pressure - - -	120 lbs.
Revolutions per minute - -	600
Nominal H.P. - - -	8

George Baird, St. Petersburg.

2178b. Model of a Yarmouth Herring Fishing Lugger getting her nets in. Exact model and position of men when at their work. *John Bracey.*

2178c. Model of a Yarmouth Trawling Smack. Without the trawl net. *John Bracey.*

2178d. Model of a Bow of a first rate ship-of-war, showing the disposition of the frames and hawse pieces. *Wm. Moody.*

2178e. Model of a Stern of a first rate ship-of-war, showing the disposition of the stern timbers and frames. *Wm. Moody.*

2147l. Stem of a First-rate showing the disposition of the frame and stern timbers. *Wm. Moody.*

2178h. Model of a Jury Rudder as fitted to the arctic schooner " Intrepid." *Wm. Moody.*

2178i. Model of a Bermudian Sailing Boat, " Pearl." *Wm. Moody.*

2178j. Model of the State Barge in which William III. landed at Greenwich, 1689. *Wm. Moody.*

2178k. Model showing the method of framing a screw aperture of a line of battle ship, to enable the screw to be raised or lowered at pleasure. *Wm. Moody.*

2178l. Model of a Midship Section, showing the method of framing a first rate ship-of-war. *Wm. Moody.*

2178m. Model of the Bow of a first rate ship-of-war, " Prince of Wales." *Wm. Moody.*

SERIES OF IRON MAIL PADDLE STEAMERS, DESIGNED AND BUILT BY THE LATE JOHN LAIRD, M.P., FROM 1840 TO 1860.

2178n. Model of H.M.S. " Dover," 1840. Length 113 ft., breadth 21 ft., depth 9 ft. 10½ ins. 228 tons. 90 horse-power. *Laird Brothers.*

This was the first iron mail steamer, and was built for the Admiralty in 1840. She carried the mails between Dover and Calais for many years, and afterwards did good service on the coast of Africa.

2178o. Model of " Lord Warden," 1847. Length 160 ft., breadth 24 ft., depth 10 ft. 9 ins. 446 tons. 160 horse-power. *Laird Brothers.*

Built for the South-eastern Railway Company in 1847, and is still running as one of their despatch boats between Folkstone and Boulogne.

2178p. Model of " Cambria," 1848. Length 196 ft., breadth 27 ft., depth 14 ft. 6 ins. 716 tons. 370 horse-power. *Laird Brothers.*

Built for the Chester and Holyhead Railway Company for their despatch service between Holyhead and Dublin, was lengthened in 1860, and is still running as a cattle boat.

2178q. Models of the "Ulster," "Munster," and "Connaught," 1860. Length 334 ft., breadth 35 ft., depth 19 ft. 2,039 tons. 750 horse-power. *Laird Brothers.*

Built for the City of Dublin Steam Packet Company, for the mail service between Holyhead and Kingston, in 1860.

The "Connaught" attained a speed of over 18 knots, or 21 statute miles, per hour on her official trial at Stokes Bay.

These three vessels, together with the "Leinster," built by Messrs. Samuda, still perform this service.

SERIES OF IRON VESSELS, DESIGNED AND BUILT BY THE LATE JOHN LAIRD, M.P., AND THE PRESENT FIRM, AS SURVEYING SHIPS, MEN-OF-WAR, &C.

2178r. Model of H.E.I.C. "Euphrates" and "Tigris," 1834. Length 105 ft., breadth 19 ft., depth 7 ft. 6 ins. 179 tons. 50 horse-power. *Laird Brothers.*

Built for the Hon. East India Company for General Chesney's expedition for the exploration of the River Euphrates. These vessels were built by Mr. Laird at Birkenhead, 1834, then taken to pieces and shipped to the coast of Syria, and after having been carried across the desert by camels, they were put together and launched on the banks of the Euphrates by artisans sent from Birkenhead for the purpose.

Three similar vessels of very light draught, the "Nimrod," "Nitocris," and "Assyria," of 153 tons, each carrying two 9-pr. pivot guns, were built for the navigation of the Tigris and Euphrates a few years later.

2178s. Model of H.E.I.C. "Nemesis," 1839. Length 169 ft., breadth 29 ft., depth 10 ft. 3 ins. 660 tons. 120 horse-power. *Laird Brothers.*

Built for the Hon. East India Company for service on the coast of India, and armed with two 32-pr. pivot guns.

This vessel, as well as the "Phlegethon," a similar but rather smaller vessel, though only drawing 5 feet of water, made the passage out to India round the Cape, a drop rudder and sliding keel, as shown on model, being fitted for that purpose.

Under the command of Captain (now Admiral Sir William) Hall, R.N., the "Nemesis" did distinguished service in the China wars, her light draught enabling her to perform service which no wooden vessel in the fleet was able to accomplish.

At the same time the "Medusa" and "Ariadne," of 432 tons, and each carrying two 24-pr. pivot guns, were built for the same service.

2178t. Model of the "Guadaloupe," 1842. Length 187 ft., breadth 30 ft., depth 16 ft. 788 tons. 180 horse-power. *Laird Brothers.*

The success of the above steamers (the first iron vessels armed with heavy guns) induced the agents of the Mexican Government to order the steam frigate "Guadaloupe," of 800 tons and 180 horse-power, armed with two 68 pounder pivot guns, one at each end, and four 24-pounder broadside guns. The satisfactory reports made upon the construction and trials of this vessel by the late Mr. Large and other officers induced the English Government to entrust Mr. Laird with the designing and building of the iron paddle-wheel frigate "Birkenhead," 1,400 tons, one of the first iron war ships in the English navy; this ship was launched in 1845.

2178u. Models of the "Parana" and "Uruguay," 1873. Length 152 ft., breadth 25 ft., depth 12 ft. 6 ins. 455 tons. 80 horse-power. *Laird Brothers.*

Iron screw gunboats of modern type, built for the Government of the Argentine Confederation, armed with two 100-pr. Vavasseur pivot guns. Rigged as barques and fitted with Bevis' patent feathering screw propeller.

2178v. Models of the "Fu-Shêng" and "Chien-Shêng," 1875. Length 87 ft., breadth 26 ft., depth 8 ft. 8 ins. 256 tons. 40 horse-power. *Laird Brothers.*

Iron screw gunboats for coast and river defence, armed with one 18-ton Vavasseur gun, 450-pr., fitted with twin screws.

These vessels steamed out to China through the Suez Canal.

2178w. Models of the "El Plata" and "Los Andes," 1875. Length 180 ft., breadth 44 ft., depth 11 ft. 9 ins. 1,588 tons. 750 indicated horse-power. *Laird Brothers.*

Armour-plated twin screw turret vessels, built for the Government of the Argentine Confederation. Protected with armour 6 inches on the hull and 8 inches on the turret, and carry each two 12½-ton 300-pr. rifled guns.

They steam 9½ knots on a load draught of water of 9 ft. 6 ins., and steamed from the Mersey to Buenos Ayres in about 50 days, including all stoppages.

SERIES OF IRON PADDLE-WHEEL VESSELS FOR COMMERCIAL PURPOSES, DESIGNED AND BUILT BY THE LATE JOHN LAIRD, M.P., AND PRESENT FIRM.

2178x. Model of the "John Randolph," 1834. Length 110 ft., breadth 22 ft., depth 7 ft. 6 ins. 249 tons. 60 horse-power. *Laird Brothers.*

The first iron steamer ever seen on American waters, built at Birkenhead, taken to pieces, shipped at Liverpool, rivetted together on the Savannah river, where for many years after she did service as a tug boat.

2178y. Model of the "Garryowen," 1834. Length 130 ft., breadth 21 ft. 6 ins., depth 9 ft. 3 ins. 263 tons. 90 horse-power. *Laird Brothers.*

Paddle steamer built for the City of Dublin Steam Packet Company, for the navigation of the lower Shannon, and the largest iron vessel built at this time. After 30 years' service in Ireland the machinery was taken out of her and she was made into a sailing ship.

About the year 1841, at Mr. Laird's suggestion, this vessel was placed at the disposal of the Admiralty to enable them to institute a series of experiments on the variation of the compass in iron vessels, which were conducted by Capt. Johnson, R.N., and subsequently elaborated by the experiments carried out by Professor Airy on General Steam Navigation Company's steamer "Rainbow," built by Mr. Laird in 1837.

2178z. Model of the "Helen McGregor," 1843. Length 180 ft., breadth 26 ft., depth 15 ft. 573 tons. 220 horse-power. *Laird Brothers.*

Built for carrying passengers and cattle between Hull and Antwerp; one of the largest vessels of her class.

2178aa. Model of the "Countess of Ellesmere," 1852. Length 160 ft., breadth 20 ft., depth 7 ft. 6 ins. 315 tons. 80 horse-power. *Laird Brothers.*

Fast paddle passenger steamer, formerly running on the Mersey, afterwards sold as a yacht to the Grand Duke Constantine of Russia.

2178ab. Model of the "Earl Spencer," 1874. Length 253 ft. 6 ins., breadth 29 ft., depth 14 ft. 9 ins. 1,067 tons. 350 horse-power. *Laird Brothers.*

Showing present type of passenger and cattle steamers; built for the London and North-western Railway Company for service between Holyhead and Greenore. Speed, 15 knots.

SERIES OF IRON SCREW STEAMERS, DESIGNED AND BUILT BY THE LATE JOHN LAIRD, M.P., AND THE PRESENT FIRM, FROM 1838.

2178ac. Model of the "Robert F. Stockton," 1838. Length 63 ft. 5 ins., breadth 10 ft., depth 7 ft. 33 tons. 30 horse-power. *Laird Brothers.*

One of the first screw steamers ever built; fitted with Ericsson's screw propeller.

The propeller was unshipped for the voyage made under canvas from Liverpool to New York, where she was employed for many years as a tug boat.

2178ad. Model of the "Forerunner," 1852. Length 161 ft. 6 ins., breadth 22 ft., depth 11 ft. 4½ ins. 381 tons. 50 horse-power. *Laird Brothers.*

Built for MacGregor Laird, Esq., the founder of the African Royal Mail Steam Navigation Company, of which she was the pioneer vessel.

2178ae. Model of the "Nubia," 1854. Length 292 ft., breadth 39 ft., depth 27 ft. 9 ins. 2,173 tons. 450 horse-power. *Laird Brothers.*

Type of screw mail and passenger steamer of her date. Built for the Peninsular and Oriental Steam Navigation Company, and still carrying the mails in their service.

2178af. Model of the "Africa," 1871. Length 285 ft., breadth 34 ft., depth 23 ft. 3½ ins. 1,627 tons. 200 horse-power. *Laird Brothers.*

One of the modern steamers of the African Royal Mail Company, for same service as "Forerunner."

2178ag. Models of the "Corcovado," "Puno," and "Britannia," 1872. Length 375 ft., breadth 43 ft., depth 33 ft. 9 in. 3,434 tons. 600 horse-power. *Laird Brothers.*

Type of screw mail and passenger steamer of present date.

Built for the mail and passenger service of the Pacific Steam Navigation Company.

The "Corcovado" made her first voyage from Liverpool to Callao, 11,000 knots, in 33½ days, equal to a mean speed of 13·54 knots.

SUNDRY MODELS AND PLANS.

2178ah. Model of Bow of Vessel, showing bow rudder, with guard on. Patent taken out by the late Mr. John Laird in 1843. *Laird Brothers.*

Very generally adopted for all double-ended river steamers, and fitted in several paddle-wheel gun vessels.

2178ai. H. E. I. Co. "Napier," 1843. Length 160 ft., breadth 24 ft., depth 5 ft. 446 tons. 90 horse-power. *Laird Brothers.*

Built for the Hon. East India Company on a plan patented by Mr. Laird in 1843, with a spoon-shaped bow, and lifting dead wood and rudder.

This form of vessel combines speed, light draught of water, and good steering, with great carrying capacity, and was found to answer so well for the difficult navigation of the River Indus that a large number of river steamers were afterwards constructed by Mr. Laird for the Hon. East India Company on same system.

2178aj. Model prepared by the late William Laird, Esq., in 1836, to show application of the screw propeller to a frigate or troop ship of large size. *Laird Brothers.*

2178ak. Picture of the "Rainbow," 1837. Length 185 ft., breadth 25 ft., depth 11 ft. 9 ins. 581 tons. 180 horse-power. *Laird Brothers.*

Paddle steamer for passenger and cargo service, built for the General Steam Navigation Company of London, for service between London and Ramsgate. After being employed in London and Antwerp trade for some time, the "Rainbow," which was the fastest vessel of her day, ran for many years as a cargo steamer between Havre and London, and was in service till 1869.

2178al. Picture of H.M.S. "Soudan," "Albert," and "Wilberforce," 1840. Length 138 ft., breadth 27 ft., depth 8 ft. 8 ins. 459 tons. 70 horse-power. *Laird Brothers.*

Built for H.M. Government for the exploration of the River Niger.

2178am. Picture of the Ferry Steamer "Nun," 1840. Length 105 ft., breadth 20 ft., depth 8 ft. 9 ins. 187 tons. 60 horse-power. *Laird Brothers.*

The picture shows the "Nun" grounded on the stone pier at Birkenhead, her after end resting on the pier, and her bow on the bare rock below, the distance between the points of support being 81 ft.; the whole weight of the machinery, 65 tons, being in the middle of this unsupported space. She floated off the succeeding tide without having received the slightest damage.

This incident, which occurred in 1842, went far to confirm the growing confidence in the strength of iron ships.

2178an. Model of the "Marajo," 1874. Length 221 ft., breadth 32 ft., depth 10 ft. 3 ins. 1,099 tons. 200 horse-power.
Laird Brothers.

Type of river steamer of modern construction, having large carrying capacity for passengers and cargo, on light draught of water, and great speed, and being fitted with compound oscillating engines.

2178ana. Model of H.M. Ironclad Turret Ship "Captain."

Built at Birkenhead, 1869.
Horse power, 900 nominal.
Engines by Laird Brothers.
Horse power, indicated 5,400.
Length, 335 feet. Breadth, 52 ft. 3 in.
Tons 4,272. *Laird Brothers.*

This vessel was ship rigged and had tripod iron masts and lower yards of iron; she carried two armour plated turrets containing two 600-pr. 25 ton guns each, one bow gun, 100-pr. 6½ tons, one stern gun, 100-pr. 6½ tons.

The "Captain" was lost in a gale off the coast of Spain in the night of 6th September 1870.

2178bf. Drawings of the Sailing Ships "Falmouth," 1752; "Friendship," 1790; "Royal William," 1726. (Three drawings.) *R. and H. Green.*

2178bg. Half-block Model of SS. "Sultan." Built 1870. *R. and H. Green.*

2178ao. Half-block Model of S.S. "Viceroy." Built 1871. Length 320 ft., breadth 37 ft. 6 ins., depth, keel to upper beams, 20 ft. 3 ins., depth, keel to main beams, 32 ft. 3 ins. Tons B.M. 2,225. Tons net register 1,851. *R. and H. Green.*

2178ap. Half-block Model of Ironclad Ram "Arapiles." Built for the Spanish Government, 1863. Length 279 ft. 4 ins., breadth 54 ft., depth 32 ft. 5 ins. Tons burthen 3,547. Screw engines, horse-power 800 nominal. 34 guns.
R. and H. Green.

2178aq. Half-block Model of H.M. Ironclad Batteries "Glatton" and "Trusty." Built 1855. Length 172 ft. 6 ins., breadth 45 ft. 1 in., depth 14 ft. 9½ ins. Tons 1,546. Engines horse-power 150 nominal. *R. and H. Green.*

2178ar. Whole Model of East Indiaman "Falmouth." Built 1752. *R. and H. Green.*

2178as. Whole Model of Merchant Sailing Ship "Seringapatan." Built 1837. *R. and H. Green.*

2178at. Half-block Model of Paddle Tug "Rienzi." Built 1875. Length 114 ft. 6 ins., breadth 20 ft., depth 11 ft. Tons B.M. $218\frac{35}{94}$. Horse-power 70 nominal. *R. and H. Green.*

2178au. Half-block Model of Sailing Ship "Agamemnon." Built 1855. Length 244 ft., breadth 36 ft. 6 ins., depth 16 ft. 6 ins. Tons $1{,}536\frac{67}{94}$. *R. and H. Green.*

2178av. Half-block Model of Sailing Ship "Nile." Built 1850. Length 173 ft. 8 ins., breadth 36 ft. 6 ins., depth 16 ft. Tons $1{,}038\frac{29}{94}$. *R. and H. Green.*

2178aw. Half-block Model of Sailing Ship "Carnatic." Built 1833. Length 130 ft. 6 ins., breadth 32 ft. 6 ins., depth 14 ft. 7 ins. Tons 595. *R. and H. Green.*

2178ax. Half-block Model of Sailing Ship "Melbourne." Built 1874. Length 260 ft., breadth 40 ft., depth 24 ft. Tons register 1,965, tons O.M. 2,008. *R. and H. Green.*

2178ay. Half-block Model of Sailing Ship "Carlisle Castle." Length 220 ft., breadth 38 ft., depth 22 ft. 10 in. Tons register 1,458, tons O.M. 1,514. *R. and H. Green.*

2178aya. Sectional Drawing and Plan of the Ship "Falmouth," 1752. *R. and H. Green.*

2178ayb. Sectional Drawing, fore and aft view of the ship **"Royal William," 1726.** *R. and H. Green.*

2178ayc. Profile, Plan, and Body of the Ship "Friendship."
Laid down 1789.
Launched 1790.
Length, 102 ft. 7½ inches.
Breadth, 26 feet 6 inches.
Depth, 12 feet 2 inches.
Tons, 307·2294. *R. and H. Green.*

2178az. Drawing, Profile of Captain Dicey's Channel Steamer "Castalia."
The Thames Iron Works and Shipbuilding Company.

2178ba. Drawing, Main Deck Plan of Captain Dicey's Channel Steamer "Castalia."
The Thames Iron Works and Shipbuilding Company.

2178bb. Drawing, Section of Captain Dicey's Channel Steamer "Castalia."

The Thames Iron Works and Shipbuilding Company.

2178bz. Glass Case containing Models of Ships built by the Company.

The Thames Iron Works and Shipbuilding Company.

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"Victoria" (half model), Spanish Government, ironclad.
"König Wilhelm" (half model), Imperial German Government, ironclad.
"Mesoudiyè" (half model), Şultan of Turkey, ironclad.
"Pervenetz" (half model), Czar of Russia, ironclad.
H.M.S. "Waterwitch" (half model), English Government, ironclad.
"Vasco da Gama (half model), Portuguese Government, ironclad.
"Absalon" (half model), Danish Government, ironclad.
"Avni Illah" (whole model), Sultan of Turkey, ironclad.
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"Castalia" „ iron steamer for channel service.
Glass case section of H.M.S. "Warrior," English Government.

2178ca. 13 Mounted Drawings, midship sections of various vessels built at the Thames Iron Works, and showing the advance in the thickness of armour plating from 1855 to 1876.

The Thames Iron Works and Shipbuilding Company.

2178caa. Photographs of Steam Ships built by the Thames Iron Works, of which models are in show case.

Twin ship "Castalia." Bow and side view.
Ship of war "Vasco da Gama." Portuguese ironclad.
"Messoudiyé." Turkish ironclad.

Thames Iron Works and Shipbuilding Company, Limited.

2178cab. Model of the Paddle Steamer, "Lady of the Lake," Isle of Wight, Southampton and Portsmouth boat.

Nominal horse power, 60.
Engines by J. Stewart, London.

Thames Iron Works and Shipbuilding Company, Limited.

2178cac. Model of the Paddle Dispatch Vessel, "Ijedden." Built for H.I.M. the Sultan of Turkey.

Nominal horse-power, 300.
Length, 250 feet. Breadth, 29 feet 6 inches.
Depth, 18 feet. Tons, 1,075.

Thames Iron Works and Shipbuilding Company, Limited.

2178bh. Half-block Model of Ship "Japanese."

T. Royden.

2178bi. Two whole Models, illustrating framings in wood of old ships. *T. Royden.*

2178bj. Model of the Iron SS. "Nina," built by the exhibitors. *Richardson, Duck, and Co.*

2178bk. Model of the Iron SS. "El Rahmanieh." Built for His Highness the Viceroy of Egypt by the exhibitors. *Richardson, Duck, and Co.*

2178bl. Whole Model in Bone of a Three-decker Line of Battle Ship, made by French prisoners in England during the Peninsular War, 1812. *Vaughan Pendred.*

2178bm. Model showing Interior of a Wooden Merchant Ship. *Lloyd's Register of British and Foreign Shipping.*

2178bn. Model showing the Framing of the Fore Body of a Wooden Merchant Ship. *Lloyd's Register of British and Foreign Shipping.*

2178bo. Model showing the Framing of the after Body of a Wooden Merchant Ship. *Lloyd's Register of British and Foreign Shipping.*

2178bp. Model of a Ship with radiating Frames. *Lloyd's Register of British and Foreign Shipping.*

2178bq. Model of a Ship Sheathed with Diagonal Doubling Plank. *Lloyd's Register of British and Foreign Shipping.*

2178br. Model of an Old Ship showing Framing of Deck-Beams, &c., also lower masts and bowsprit in place. *Lloyd's Register of British and Foreign Shipping.*

2178bs. Model of Thomas Bilbe's System of constructing Composite Vessels. *Lloyd's Register of British and Foreign Shipping.*

2178bt. Sectional Model of an Iron Vessel. *Lloyd's Register of British and Foreign Shipping.*

2178bu. Drawing of a Composite Vessel, showing the iron framework, and the mode of fastening the wood bottom. *Lloyd's Register of British and Foreign Shipping.*

2178bv. 20 Drawings, illustrating Lloyd's Rules for Shipbuilding on the Composite System. *Lloyd's Register of British and Foreign Shipping.*

2178bw. Model of H.M. Gun Boat "Staunch." Built by C. Mitchell and Co., Newcastle-on-Tyne. *C. Mitchell and Co.*

The "Staunch" was built in 1868, as the type of a new class, which has since been largely introduced with the British and other services. Length of vessel 75 feet, beam 25, depth 8 feet, armament one $12\frac{1}{2}$ ton gun. Engines are of 40 horse-power nominal with twin screws.

2178bx. Model of Armour Clad Frigate "Prince Pojarski." Built for the Imperial Russian Government by C. Mitchell and Co., Newcastle-on-Tyne. *C. Mitchell and Co.*

The dimensions of vessel are, length 280 feet, beam 49 feet, depth 31 feet, armament eight 300-pr. contained in central battery. Machinery, 600 horse-power nominal, and speed of vessel about 13 knots per hour.

2178by. Model of Paddle Steamer "Baron Osy." Built by C. Mitchell and Co., Newcastle-on-Tyne, in 1875, for the Société Anversoise de Bateaux à Vapeur, to provide an improved passenger service between London and Antwerp. Dimensions are, length 240 feet, beam 30 feet, engines 250 horse-power, and speed 13 knots per hour. *C. Mitchell and Co.*

2178cc. Model of the Paddle Steam Yacht "Menai," supplied by R. Napier in 1830 to Thomas Assheton Smith. *R. Napier.*

The hull, 132 feet long, 20 ft. 6 ins. broad, 12 ft. 8 ins. depth of hold, and $146\frac{11}{94}$ tons register, was built by John Wood, Port Glasgow, from Mr. Smith's design, the vessel's bottom having a hollow or channel on each side of centre keel.

The engines were made and fitted by R. Napier. Cylinders $42\frac{3}{4}$ ins. diam. × 4 feet stroke, 120 nominal horse-power.

2178cd. Album containing Drawings of the Engines of the Paddle Steamer "British Queen." Constructed in 1838 for the British and American Steam Navigation Company, London, by R. Napier, Glasgow. Also drawings of engines and boilers of other vessels of the Cunard line for Transatlantic service. *R. Napier.*

The hull, 275 ft. long, 39 ft. 8 ins. broad, 27 ft. 6 ins. deep (moulded), was built by Messrs. Curling and Young, London.

Cylinders, $77\frac{3}{4}$ ins. diameter × 7 feet stroke, 420 nominal horse-power.

These engines (the largest marine engines made at the time they were constructed) were fitted with Hall's surface condenser.

2178fh. Photograph of H.M. Indian Relief Troopship "Malabar." Built and engined, 1867, by R. Napier and Sons. Length 360 ft., breadth 49 ft., depth, 22 ft. 4 in.; tonnage, 4,173; horse-power, 700. *R. Napier and Sons, Glasgow.*

2178ce. Model of the Paddle Steamer "Faid Zafar." Length 225 ft. 6 ins., breadth 20 ft., depth 8 ft. 7 ins. 360 tons gross. *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor in 1864, for His Highness Ismail Pacha, Viceroy of Egypt, being completely composed of steel for light draught of water, schooner rigged.

Engines oscillating, cylinders 44 ins. diameter, stroke 3 ft., horse-power 120 nominal, speed 20 miles per hour.

2178cf. Model of the Paddle Steamer "Mukhbir Suroor." Length 220 ft., breadth 20 ft., depth 9 ft.

David and William Henderson and Co.

Built of iron and engined by the late firm of Tod & McGregor in 1864, for His Highness Ismail Pacha, Viceroy of Egypt, as tender to the "Faid Zafar," schooner rigged.

Engines oscillating, cylinders 40 ins. diameter, length of stroke 3 ft., horse-power 100 nominal.

2178cg. Model of the Screw Steamer "City of Manchester." Length 262 ft., breadth 36 ft., depth 25 ft. 2,096 tons gross. *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor in 1851, for the Inman Company, to trade between Liverpool and New York; barque-rigged, with jigger, about the first vessel ever fitted with *iron masts.*

Engines beam-geared, cylinders 71 ins. diameter, length of stroke 5 feet, horse-power 370 nominal.

2178ch. Model of the Screw Steamer "City of Richmond." Length 440 ft., breadth 43 ft. 6 ins., depth 34 ft. 4,606 tons gross. *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor in 1873, for the Inman Line to trade between Liverpool and New York. Ship rigged.

Engines, direct acting compound inverted, cylinders 76 ins. and 120 ins. diameters, length of stroke 5 ft.; propeller 22 ft. diameter; horse-power 670 nominal; speed at trial trip, 17 knots per hour; 10 boilers, 30 furnaces.

2178ci. Model of the Screw Steamer "Princess Royal." Dimensions, length 200 ft., breadth 28 ft., depth 15 ft. 527 tons gross. *David and William Henderson and Co.*

Built by the late firm of Tod & McGregor in 1861, for the Glasgow and Liverpool trade, schooner rigged.

Engines, direct acting inverted, compounded in 1873 by having 2 high pressure cylinders 24 inch diameter placed on top of the 45 inch cylinders—length of stroke 2 ft. 6 ins., horse-power 170 nominal, propeller 12 feet diameter, speed 12 knots per hour.

2178cj. Model of the Screw Steamer "Lady Nyessa." Dimensions, length 150 ft., breadth 14 ft., depth 6 ft.

David and William Henderson and Co.

Built by the late firm of Tod & McGregor in 1861, for the late Dr. Livingstone, for exploration in Central Africa. To facilitate transportation of the vessel from the Zambesi to Lake Nyessa, she was constructed in 12 segments in her length, each segment being in two pieces which were bolted together through angle iron frames. Dr. Livingstone on his return home from Africa, on his first exploration, sailed in her from the Zambesi to Calcutta. The "Lady Nyessa" was fitted with two propellers, one abaft the other on the same shaft.

Engines high pressure, cylinders 14 in. diameter, length of stroke 12 inches, horse-power 25 nominal.

2178ck. Model of the Screw Steamer "Bengal." Dimensions, length 297 ft., breadth 39 ft., depth 27 ft. 6 ins. 2,235 B.M. tons. *David and William Henderson and Co.*

Built by the late firm of Tod & McGregor in 1852, for the Peninsular and Oriental Steam Navigation Co., lately trading in the China Seas.

Engines beam geared, cylinders 80 inches diameter, stroke 5 feet, horse-power 470 nominal.

2178cl. Model of the Paddle Steamer "Trafalgar." Dimensions, length 190 ft., breadth 28 ft. 6 ins., depth 16 ft. 4 ins. 689 tons gross. *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor in 1847, for Messrs. Wm. Watson & Co., Dublin, for their Liverpool and Dublin trade, schooner rigged.

Engines oscillating, cylinders 69 inches diameter, length of stroke 5 feet 6 inches, horse-power 360 nominal.

2178cm. Model of the Paddle Steamer "Princess Royal." *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor in 1841, for the Glasgow and Liverpool trade; wrecked in 1856, and a new paddle steam vessel built in 1857 to replace her.

Engines, steeple, cylinders 72 inches diameter, length of stroke 6 feet 6 inches, horse-power 400 nominal.

2178cn. Model of the Paddle Steamer "Countess of Galloway." Length 165 ft., breadth 24 ft., depth 14 ft. 3 ins. *David and William Henderson and Co.*

Built and engined by the late firm of Tod & McGregor. Two vessels were built from this model and of the same name, one in 1835 and one in 1843, fitted up as passenger and cattle-boats plying between Liverpool and Wigtown; the latter vessel is still on her station, and is considered one of the best cattle-boats afloat. Owned by the Galloway Steam Navigation Company, rigged 3-masted schooner.

Engines vertical, direct-acting, cylinders 54 inches diameter, length of stroke 5 feet, horse-power 220 nominal, paddle wheel 22 feet diameter.

2178co. Model of the Twin Paddle Steamer "Alliance." Dimensions 140 ft. by 9 ft., breadth of each hull, depth, 8 ft., distance between hulls, 12 ft., total breadth, 30 ft. *David and William Henderson and Co.*

Propelled by one paddle wheel, 18 feet diameter, placed between hulls, 27 ft. 6 ins. abaft centre of vessel. The paddle wheel was afterwards taken out of the centre and the two halves rivetted together; since that alteration she made several successful passages as a blockade runner during the late

American war. The "Alliance" was built by the late firm of Tod & McGregor in 1856, for Clyde river traffic.

Cylinders 34 inches diameter, length of stroke 3 feet, horse-power 70 nominal.

2178coa. Drawing, Rigging Plan of four-masted Screw Steamer, "City of Manchester," 1876. Scale, $\frac{1}{8}$-inch to 1 foot. *D. & W. Henderson & Co.*

The vessel was fitted with iron masts.

2178cob. Drawing, Profile Plan, and Sail Draft of Screw Steamer "No. 113." 1861.

Length, 115 feet. Breadth, 14 feet.
Depth, 6 feet. Tons, 111.
Scale, $\frac{1}{4}$-inch to 1 foot. *D. & W. Henderson & Co.*

2178coc. Drawing, Rigging Plan of two-masted Screw Steamer "Princess Royal." 1871. Scale, $\frac{1}{8}$-inch to 1 foot. *D. & W. Henderson & Co.*

This steamer was lengthened 20 feet, and the rigging to suit.

2178cod. Drawing, Midship Section of Screw Steamer "Princess Royal." 1871. Showing position of boilers and decks. Scale, $\frac{1}{2}$ inch to 1 foot. *D. & W. Henderson & Co.*

2178coe. Drawing, Rigging Plan of three-masted Screw Steamer "City of Richmond." 1873. Scale, $\frac{1}{8}$-inch to 1 foot. *D. & W. Henderson & Co.*

2178cof. Drawing, Profile Plan and Lines of Paddle Steamer "Alliance." Twin ship. 1876.

Length, 140 feet; breadth of each turn, 9 feet; breadth between hulls, 12 feet; depth of hulls, 8 feet. *D. & W. Henderson & Co.*

This ship driven by a single wheel aft between the hulls.

2178cog. Drawing, Rigging Plan of Steel Paddle Yacht No. 135, "Faid Zafar." 1865. Scale, $\frac{1}{8}$-inch to 1 foot. *D. & W. Henderson & Co.*

2178coh. Drawing, Profiles of Stern and Bow, and Plan of the Paddle Steamer "Countess of Galloway." 1843.

Length, 150 feet; breadth, 24 feet; depth, 14 feet 7 inches. Scale $\frac{1}{4}$ inch to 1 foot. *D. & W. Henderson & Co.*

2178cp. Model of the Merchant Vessel "Brotherly Love." Built in the year 1764, and still running. The mark on the side is from damage in a collision with a steamer some years ago. *James Young.*

This is the ship in which Captain Cook first sailed from the port of Whitby.

2178cq. Model of the Merchant Vessel "Antelope." Built in the year 1757. *James Young.*

2178cr. Model of a Shields Pilot's Coble. *James Young.*

2178cs. Model of the Mast of the Man-of-war "Nelson," in seven pieces, without the pieces which form the top. *James Young.*

DIMENSIONS, WEIGHT, AND EXPENSE OF THE "NELSON'S" MAIN MAST.

		£	s.	d.
No. 1.	Expense of seven trees	860	16	6
2.	Hoops, bolts, and nails	61	11	6
3.	Smith work	16	4	0
4.	Mast makers	55	0	7¾
		993	12	7¾

	ft.	ins.
Length	127	2¼
Greatest diameter	0	41
Smallest diameter	0	30⅜

	tons	cwt.	qr.	lbs.
Weight	26	0	3	24

2178cu. Half Model of an Iron Screw Steamer, showing about 23 ft. of midship body, with a Price's patent self-trimming hatchway fitted. *William Denton.*

The adoption of this new style of hatch opening in the vessels already fitted with Price's patent has effected very large saving in the cost of loading, as trimming is entirely dispensed with. The pamphlet containing testimonials explains the opinions of the owners, who have adopted the invention. The lithograph shows profile of vessel fitted with Price's hatchways, also detailed sketches of manner of fitting half-beams, hatch sides, &c.

2178cv. Half Model of Iron Merchant Vessel "Donnybrook." Length 260 ft., breadth 40 ft., depth 24 ft. Designed in 1876 by Messrs. Austin and Hunter. Tonnage 1,700 tons, water draught 21 ft. *Austin and Hunter.*

2178cw. Half Model of Iron Cargo Steamer "Decapolis." Length 260 ft., breadth 32 ft., depth 23½ ft., tonnage 1,000 tons, draught of water 20. Built 1876 by Messrs. Austin and Hunter. *Austin and Hunter.*

2178cx. Model of Merchant Ship "Cherubim." Length 156 ft., keel 136 ft., breadth 28 ft., depth 18 ft. *Thomas Wrightson.*

2178cy. Model of Passenger Steamer "North Star." Length 316 ft., depth 23 ft., breadth 36 ft., tonnage 2,500 tons. *Thomas Wrightson.*

2178cz. Model of the "Crest of the Wave," a noted China clipper, built by the late William Pile, Sunderland, and owned by John Hay, Esq., and others, Sunderland. Built in 1853 of wood. Length 180 feet, breadth 32 feet, depth 20 feet. Classed 13 years A1. in Lloyd's registry; 776 tons register.
R. H. Hay.

2178da. Model of the wood clipper vessel "Aurora Borealis," built by the late William Pile, Sunderland, and owned by John Hay, Esq., Sunderland, in 1850. *R. H. Hay.*

2178db. Model of the wood clipper vessel "Herald of Light," built by the late William Pile, Sunderland, in 1850, and owned by Henry Ellis, Esq., London. *R. H. Hay.*

2178de. Model of the "Dover Castle" (wood). Built for Richard Green, Esq., Blackwall, in 1858. Length 185 ft., depth 22 ft., breadth 34 ft., tonnage 1,002 nett. *John Haswell.*

This vessel was draughted and model made by Master George Haswell, son of the builder, when 15 years old.

2178df. Model of the "Min" and "Sumida," iron sister ships. Built for the Japanese Government by R. Thompson, junior, in 1874. Length 268 ft., breadth 32 ft. 1 in., depth 21 ft. 4 ins.

Gross tonnage - - - -	1,411
Net " - - -	896
H.P. - - - - - -	200

Robert Thompson, junior.

2178dg. Model of the "Lady Louisa," iron composite. Built for Wilson and Co., London, by R. Thompson, junior, in 1865. Length 152 ft., breadth 28 ft. 3 ins., depth 17 ft. 9 ins. Net tonnage 542. *Robert Thompson, junior.*

2178dh. Model of the "Life Brigade," iron. Built for E. Shotton and Co., North Shields, by R. Thompson, junior, in 1873. Length 249 ft. 5 ins., breadth 32 ft. 4 ins., depth 17 ft. 15 ins.

Gross tonnage - - -	1,512
Net " - - -	977
H.P. - - - - -	150

Robert Thompson, junior.

2178di. Model of the "Graham" (wood). Built for Edmund Graham, Newcastle, by Robert Thompson and Sons, designed by Robert Thompson, junior, in 1850. Length B.P. 132 ft., breadth 30 ft. 4 ins., depth of hold 20 ft. 10 ins. Net tonnage 668. *Robert Thompson, junior.*

2178dj. Model of the "Opal." Composite corvette, by William Doxford and Sons. Length 220 ft., breadth 40 ft., depth 21 feet. *Wm. Doxford and Sons.*

2178dk. Model of the Screw Steamer "Adalia." Built for E. T. Gourley, Esq., M.P., by William Doxford and Sons. Length 231 ft. 6 ins., breadth 32 ft., depth 24 ft. 8 ins. *Wm. Doxford and Sons.*

2178dl. Model of Composite Gunboats "Cygnet," "Express," and "Contest." By William Doxford and Sons. Length 125 ft., breadth 23 ft. 6 ins., depth 12 ft., horse-power 360. *Wm. Doxford and Sons.*

2178dm. Model of Passenger Screw Steamer "Gloria" built for Olano Larrinaga & Co., Liverpool, by William Doxford and Sons. Length 322 ft., breadth 38 ft. 3 ins., depth 30–55. *Wm. Doxford and Sons.*

2178dp. Set of Original Block Models from which the following vessels were built in wood:—

"Victory," barque, built in 1847, length 113 ft., breadth 22 ft. 8 ins., depth 13 ft. 6 ins. Classed 7 years A1, tonnage 239 tons.

"St. George," Snow collier, built in 1847, length 78 ft., breadth 23 ft., depth 12 ft. 3 ins. Classed 8 years A1, tonnage 153 tons.

"Providence," schooner, fruit trade, built in 1850, length 69 ft., breadth 17 ft., depth 10 ft. Classed 7 years A1, tonnage 83 tons.

"Bury St. Edmunds," full-rigged ship, built in 1853, length 155 ft., breadth 31 ft., depth 21 ft. Classed 13 years A1, tonnage 701 tons. *Peter Forster.*

2178em. Model. Midship section of a composite vessel experimentally built and classed at Lloyd's for 11 years. *Nelson Dock Company, Limited.*

2178en. Model. Half midship section of a composite vessel experimentally built and classed at Lloyd's for 15 years. *Nelson Dock Company, Limited.*

2178eo. Model. No. 3. Half model of an old paddle steamer. *Nelson Dock Company, Limited.*

2178ep. Model. No. 4. After body and stern framing of an old East Indiaman. *Nelson Dock Company, Limited.*

2178eq. Half-block Model of a Yarmouth Trawling Smack, drawings of "Lord Peto," and other Yarmouth vessels. *I. H. Fellowes.*

2178er. The "Mary Taylor," New York pilot boat, built by George Steers, an Englishman in New York, about 1850. He afterwards built the celebrated "America" yacht. He told the exhibitor in New York, in September 1854, that he considered the "Mary Taylor" the faster vessel of the two, particularly in rough water. *Henry Liggins.*

2178do. Half Block Model of the Popovka "Admiral Popoff." *Russian Embassy.*

This ship is the second of the series of circular ironclads in course of construction by Russia.

The principal dimensions are the following :—

Extreme diameter, 121 ft. Mean draught of water, 13 ft. Height of upper deck at side from load water line amidships, 1 ft. 6 ins. Height of barbette turret from load water line, 13 ft. 3 in. Displacement in tons, 3,550.

This vessel carries two 41-ton guns, which can be trained completely round inside the turret, their carriages being arranged so as to admit the guns to be lowered down for loading and aiming behind the protection of the thick turret armour, and to be brought up only for firing.

Besides these heavy guns there are, on each side of the superstructure containing cabins and quarters for crew, two smaller guns throwing projectiles of sufficient power to penetrate an unarmoured enemy.

The vessel and turret are protected by means of armour made in two solid layers, having a total thickness of 1 ft. 6 in. (including equivalent thickness for the hollow iron girders behind armour). Side armour of the vessel extends from the edge of the vessel's upper deck down to 4 ft. 6 in. below load water line amidships. The upper deck is protected by deck armour 3 in. thick, extending from the circumference of the turret to the circumference of the vessel.

The propelling power is developed by eight compound vertical engines, each of 80 horse-power (nominal); four of these work each an independent screw of 10 ft. 6 in. in diameter, and four remaining engines arranged and worked in pairs propel the middle screws on each side of the vessel. These two screws are made larger and their shafting lowered down so as to increase the speed of the vessel when steaming in deep water.

This ship, though launched, has not been yet completed for sea, and accordingly no results of her trial with regard to speed have yet been obtained, but it is expected that she will attain from 9 to 10 knots, which for coast defence purposes is considered quite sufficient.

The vessel is built of iron, with double bottom, and is sheathed with wood and copper.

The chief principal objects of the design of the Popovka are :—1. The extremely large armour and gun-carrying power attained upon a very limited draught of water. This condition renders such ships extremely valuable for coast defence. 2. Extraordinary steadiness of gun platform, ensuring the efficiency of working the guns at sea, when guns of an ordinary ship must remain silent. 3. Complete protection of hull and battery by uniform thickness of armour throughout, which does not exist in any other ironclad. 4. Great cheapness of construction as compared with other vessels. 5. Number of compartments around the central vital parts of the vessel which are specially effective for the purpose of saving the vessel in case of torpedo attack.

2178dp. Half model of Russian Circular Ship of War mounted on glass support, showing the position of her large and small guns. *The Institute of Naval Architects.*

2178dq. Model of the Composite Clipper Sailing Ship "Torrens" (Elder line of packets to Adelaide). Built by James Laing, Sunderland, in 1875. Length 222 ft., breadth 38 ft., depth 21 ft. 6 ins. 1,334 tons, gross. *James Laing.*

2178dr. Model of the Peninsular and Oriental Steam Navigation Company's Vessels "Khiva" and "Kashgar." Built by James Laing, Sunderland, in 1874. Length 370 ft., breadth 36 ft. 8 ins., depth 27 ft. 4 ins. 2,600 tons gross. *James Laing.*

2178ds. Model of the Hamburg South American Steam Ship Company's S.S. "Buenos Aires." Built by James Laing, Sunderland. Length 340 ft., breadth 36 ft. 4 ins., depth 25 ft. 6 ins. 2,400 tons gross. *James Laing.*

2178dt. Model of Sailing Ship "Vimiera." Built in 1850 by James Laing, Sunderland, for the late Duncan Dunbar. Length 165 ft., breadth 33 ft., depth 23 ft. 1,037 tons. *James Laing.*

The side of this model can be opened to show the construction of the ship.

2178du. Model of the Peninsular and Oriental Steam Navigation Company's S.S. "Poonah," as altered and refitted by James Laing, Sunderland. Length 414 ft., breadth 41 ft. 6 ins., depth 27 ft. 4 ins. 3,118 tons gross. *James Laing.*

2178ek. Half Models of the Ship "Ellen Rodger," China clipper, belonging to Alexander Rodger, Esq., Glasgow; launched June 1858; length 153 ft., breadth 29 ft. 3 in., depth 19 ft. 6 in.; tonnage, $584\frac{83}{100}$; wooden ship. **Ship "Taeping,"** China clipper, belonging to Alexander Rodger, Esq., Glasgow; launched December 1863; length 185 ft., breadth 31 ft., depth 20 ft.; tonnage, $764\frac{22}{100}$; composite ship. **Ship "Ariel,"** China clipper, belonging to Messrs. Shaw, Maxton, and Co., London; launched June 1865; length 195 ft., breadth 33 ft. 9 in., depth 21 ft.; tonnage, $852\frac{87}{100}$; composite ship. **Ship "Zahloo,"** belonging to Alexander Rodger, Esq., Glasgow; launched July 1867; length 190 ft., breadth 33 ft., depth 20 ft.; tonnage, $799\frac{21}{100}$; composite ship. *Robert Steele and Co., Greenock.*

2178el. Half Models and Drawings of the Paddle Steamer "Hibernia," belonging to the Cunard Company, Glasgow; launched September 1842; length 219 ft. 8 in., breadth 35 ft. 10 in., depth 24 ft. 2 in.; tonnage, gross $1{,}421\frac{2790}{3500}$, net $791\frac{900}{3500}$; wooden ship. **Screw Steamer "Polynesian,"**

belonging to the Montreal Ocean Company, Glasgow; launched February 1872; length 400 ft., breadth 40 ft., depth 35 ft. 9 in.; tonnage, gross $4{,}282\frac{58}{100}$, net $2{,}023\frac{21}{100}$; iron ship.
Robert Steele and Co., Greenock.

2178dv. Model of Screw Steamer "Lestris." Built by Joseph L. Thompson and Sons, Sunderland. Length 227 ft., breadth 30 ft., depth of hold 17 ft. *Joseph L. Thompson and Sons.*

2178dw. Model of Sailing Ship "Baroda." Built by Harland and Wolff, Belfast.

	ft.	in.
Length, extreme - - - -	251	0
,, between perpendiculars -	231	5
Breadth - - - -	36	5
Depth - - - -	23	5
	tons.	
Tonnage builders, measurement -	1,299	
Gross register - - -	1,364	

Launched 1864. *P. Phorson.*

2178dx. Model of a Vessel built about 1844 by James Leithead, Sunderland. *P. Phorson.*

2178dy. Model of the wooden Ship "Chowringhee." Built by the late Wm. Pile, of Sunderland, for the late John Hay, Esq., in 1857. Length 156 ft. 3 ins., breadth 31 ft. 6 ins., depth 21 ft. 6 ins. *Sunderland Corporation.*

2178dz. Plans and Elevations of Steamships "Marquess de Nunez" and "Wear." Built by the late Mr. Wm. Pile, Sunderland. *Skinner, Sunderland.*

2178ea. Model of Screw Collier "David Burn." Built in 1873 by Messrs. Wm. Doxford and Sons, Sunderland.
Alfred Simey and Co.

This vessel was sunk off the Tyne by collision on her first trial trip. The visitors (chiefly ladies) were saved by the captain of the vessel which struck her, keeping his engines going at easy speed, and thus filling the hole made by the collision.

2159h. Drawing of the "London Engineer," 70 horse-power, a vessel fitted with a central paddle wheel, and air-tight paddle case, in the year 1818, intended to run to Margate. The scheme did not succeed, owing to the difficulty of keeping a sufficient supply of air in the paddle case to keep down the level of the water. *Maudslay, Sons, and Field.*

2178ga. Model of Mr. Joseph Maudslay's **Original Oscillating Cylinder Engines.** Date 1827. (The arrangement for working the air pump is not that originally fitted.)
Maudslay, Sons, and Field.

2178fn. Drawing showing the first iron vessels built in London, designed for the navigation of the River Ganges, with oscillating engines of 60 horse-power collective; date 1832.
Maudslay, Sons, and Field.

2178fo. Drawing showing another set of same, with beam engines; date 1838. *Maudslay, Sons, and Field.*

2178gm. Drawing of 30 horse-power oscillating **Engine** fitted in the **"Sylph,"** Woolwich packet, 1836.
Maudslay, Sons, and Field.

2178gb. Model of Patent Annular Cylinder Engines, by Maudslay, Sons, and Field, as fitted in first improved Channel Packet "Princess Alice" (Dover to Calais), 1843.
Maudslay, Sons, and Field.

2178gc. Model of Double Piston-rod Steeple Engines, fitted in the Hon. East India Company's vessels on the River Indus. 1840. *Maudslay, Sons, and Field.*

2178gd. Sectional Model of Side by Side Cylinder Horizontal Compound Engines. John Milner, C.E., 1853. J. Warriner. *Maudslay, Sons, and Field.*

2178gh. Drawing. First direct-acting screw engines fitted by Maudslay, Sons, and Field, in 1846 (H.M.S. "Ajax" and "Edinburgh," 450 horse-power nominal collective).
Maudslay, Sons, and Field.

2178gi. Drawing, showing arrangement of machinery in vessels. *Maudslay, Sons, and Field.*

2178gk. Drawing, showing **Engines** of H.M.S. **"Retribution,"** 1842 (similar to those of the "Terrible," 800 horse-power nominal collective); patent 4-cylinder engines.
Maudslay, Sons, and Field.

2178gl. Drawing of Beam Engines of 220 horse-power collective of H.M. ships **"Rhadamanthus," "Phoenix," "Salamander," "Medea,"** date 1832.
Maudslay, Sons, and Field.

2159d. Model of Beam Engines, similar to those of the "Great Western" steamship. This model was made by the late Henry Maudslay. *Maudslay, Sons, and Field.*

2159e. Model of Feathering Screw, by the late Joseph Maudslay. Date 1848. *Maudslay, Sons, and Field.*

2159f. Model of Paddle Wheel of "Great Western" steamship, designed by the late Joshua Field, F.R.S.
Maudslay, Sons, and Field.

2159g. Two Drawings showing the **four cylinder compound Engines** designed and fitted by Maudslay, Sons, and Field in the steaemrs of the "White Star" line, and in those of the "Compagnie Générale Transatlantique."
Maudslay, Sons, and Field.

2159a. Model of Direct-acting Screw Engines, date 1850, made for the Danish Government by Maudslay, Sons, and Field. *Maudslay, Sons, and Field.*

2159b. Model of Direct-acting Screw Engines, as fitted in 1851 by Maudslay, Sons, and Field in the mail steamers from London to Calcutta, and from London to the Cape of Good Hope. *Maudslay, Sons, and Field.*

2159c. Model of Horizontal, Double Piston Rod, Direct-acting Screw Engines, as fitted in H.M.S. "Agincourt," 1,350 horse-power nominal, and in H.M. ships "Prince Consort," "Caledonia" and "Ocean," each 1,000 horse-power nominal. *Maudslay, Sons, and Field.*

2178a. Photograph of the "Germanic" and "Britannic" mail steamers, belonging to the "White Star" line from Liverpool to New York. An abstract log of one of the voyages of the "Germanic" is attached to the frame. Length 470 ft., breadth 45 ft.; tons register, 5,004; 760 horse-power nominal, four cylinder compound engines by Maudslay, Sons, and Field. Ships built by Harland and Wolff, of Belfast.
Maudslay, Sons, and Field.

2148ea. Model, showing $\frac{1}{10}$ of the length of the **Floating Dock,** built for the Spanish Government for the Royal Dockyards at Carthagena and Ferrol, 1856–7.

Dimensions:

Total length - - - 350 feet.
Extreme breadth - - 105 feet.
Depth inside - - - 37 feet 6 ins.
Displacement - - - 13,000 tons.
Total weight - - - 5,000 tons.

Weight of ship lifted, 6,500 tons.
Scale of model, 1 inch to 1 foot.

J. & G. Rennie.

2148eb. Photograph of the Iron Floating Dock at Bermuda, built by J. Elder and Co., Glasgow; carrying H.M.S. "Royal Alfred," 6,720 tons displacement.
Campbell, Johnstone, & Co.

The dock is capable of sustaining H.M.S. "Fury," of 10,400 tons displacement.

2148ec. Photographs (2) **of Iron Floating Docks for Bermuda,** constructed by Campbell's Shipbuilding and Floating Dock Company, 1868.

Length, including cutwaters, 381 feet; width, outside, 128 feet 1 inch; height, outside, 74 feet 5 inches; length, inside, 330 feet; width, inside, 83 feet 1 inch; height, inside, 54 feet 5 inches.
Campbell's Shipbuilding and Floating Dock Company.

2178fq. Model of the inverted cylinder compound engines, P. and O. Co.'s ship **"Pera"** on the compound system of 2,000 horse-power, 1872. *J. and G. Rennie.*

2178fr. Model of the first screw-steamer in the British Navy, **"Mermaid,"** afterwards named the **"Dwarf."** Built in 1840. Purchased from J. and G. Rennie by the British Admiralty, according to Sir George Cockburn's advice, on the condition she should steam 12 miles per hour (7th March 1842); tried 15th May 1843. Mean speed of 6 runs—12·142 miles. *J. and G. Rennie.*

2178fs. Model of H.M. Gun Boats "Arrow" and "Bonetta." Built by J. and G. Rennie, 1871. Length 85 ft., breadth 26 ft., depth 8 ft. 10 in.; tons, 244. To carry one 18 ton gun. *J. and G. Rennie.*

2178ft. Model of the Iron Paddle-wheel Steamer "Queen." Built and fitted with engines by J. and G. Rennie, 1842. Length 160 ft., breadth 17 ft., depth 9 ft. Speed between 17 and 18 miles per hour, which exceeded that of any vessel on the Thames. *J. and G. Rennie.*

2178fu. Model of Indian Famine Relief Steamers. Built by J. and G. Rennie, 1874. Date of order, 24th February. Date of launch, 30th March. Tried under steam, 4th April. Length 90 ft., beam 14 ft., depth 5 ft. 6 in.; indicated horse-power, 100. Built complete with engines in 35 working days.
J. and G. Rennie.

2178fw. Model of Twin-Screw Gun Boats. Built for the East Indian Government by J. and G. Rennie, 1857. Length, 70 ft., breadth 11 ft., draught 2 ft. 6 in.; nominal horse-power, 20; indicated horse-power, 76; speed, 9¼ miles. Armament, one long brass 12-pr., 18 cwt. *J. and G. Rennie.*

2178fx. Model of Brazilian Twin-Screw Ironclad Gun Boats "Colombo" and "Cabral." Built by J. and G. Rennie, 1866. Length 160 ft., breadth 34 ft., depth 17 ft.; tons, 858 B.M.; nominal horse-power, 240; speed, 10 knots. Armament, 4 68-prs. *J. and G. Rennie.*

2178fy. Model of Twin-Screw Gun Boats. Built for the Spanish Government by J. and G. Rennie, 1859. Length 90 ft., breadth 14 ft., draught 2 ft. 6 in.; horse-power, 30.
J. and G. Rennie.

2178gp. Model of the **Engines** of H.M. ships **"Boadicea"** and **"Bacchante,"** on the compound system, of 5,250 horse-power indicated, 1875 and 1876. *J. and G. Rennie.*

2178gq. Model of Horizontal Marine Engines, with injection condensers. Made by J. and G. Rennie, 1860.
J. and G. Rennie.

2178gr. Model of Reversed Horizontal Marine Screw Engines. Built 1860. *J. and G. Rennie.*

2178gs. Drawing, design for **60 horse-power Low Pressure Condensing Disc Engines for Screw Steamship.**

The drawing shows front, side, and back elevation and plan.

Section of H.M.S. "Cruiser," fitted with the disc engines, 1853.
J. and G. Rennie.

2178gu. Compound Surface-Condensing Marine Engines. *T. Richardson and Sons, Hartlepool.*

Three drawings of marine engines of the most modern construction.

One drawing represents engines of the largest class fitted with steam reversing gear.

Another drawing represents engines of a more moderate size, and gives the names of the vessels into which they have been fitted.

A third drawing represents marine engines of the smaller class.

The three drawings all represent compound surface-condensing engines.

2178ei. Whole Model of the German ironclad ships of war **"Kaiser"** and **"Deutschland."** Built 1874 for the Imperial German navy. 7,500 tons (displacement); 8,000 indicated horse-power; engines by Penn and Sons, Greenwich.
Samuda Brothers.

2178ej. Whole Model of the **"Mahrousse,"** state paddle steam yacht. Built for His Highness the Khedive of Egypt; tons burthen, 3,150; horse-power, 800 nominal. *Samuda Brothers.*

2168. Helm Indicator for the prevention of Collisions at Sea. *John James Nickoll.*

This is a lantern which is hoisted under the mast-head light of a steamer, and connected with the helm by rods or chains, and acts automatically with the rudder like a tell-tale, showing a green light when she is starboarding, and a red light when she is porting her helm, thereby showing the course a vessel is *about* to steer, and *before* she answers her helm or deviates from her course.

2168a. Pair of Ship's Side Lights with lenses.
John James Nickoll.

Guaranteed to show the light at two miles, that being the distance required by the regulations for preventing collisions at sea. The lenses are so constructed as to permit the smallest amount of absorption of the rays of light of the colour, and the burner requires no chimney.

2178ec. Transparency showing the effects of the helm indicating signals for preventing collisions at sea.
John James Nickoll.

2178eca. Set of Ships' Lights; Port, Starboard, and Masthead Light, arranged to indicate by night the position of ships' helms, to avoid collisions. *Nickoll & Crewe.*

2178ed. Pair of Coloured Lenses for railway and other signals, calculated to show the signals upwards of two miles.
John James Nickoll.

The green signals can be seen at a much shorter distance than the red; this green lens will show a distance of *three miles.*

2178ee. Model of an Anchor invented by Sir Edward Belcher when a midshipman, 1815.
Admiral Sir Edward Belcher, K.C.B.

2178ef. Model of a method of forming an improved Anchor when the shank has been broken, proposed by the exhibitor in 1830. The method is by means of 3 pieces of ballast iron. *Admiral Sir Edward Belcher, K.C.B.*

2178eg. Model in Silver. Patent "Stockless" anchor.
Wasteneys Smith, C.E.

2178eh. Model in Brass. Patent "Stockless" anchor.
Wasteneys Smith, C.E.

These anchors are said to possess—

1. Great holding power, with less weight, besides being diminished in the weight of the stock.
2. Extraordinary strength, proved at Lloyd's test.
3. It is always canted, no matter how it falls, and requires no stock to keep it canted.
4. Being always canted when on the ground, and by the assistance of the horns or toggles, it takes hold as soon as any strain is put upon the cable.
5. Spare, and wider, and different shaped arms for various grounds may be carried on board.
6. It will not foul or get fouled, and when holding there is nothing above ground, nor is there any stock to cause accidents.
7. It trips with great ease, because there is no stock to lift, and the crown end has so large a surface that good purchase is obtained for weighing.
8. It is easily fished, and can be stowed in-board on deck, thus clear of the bow, and avoiding risk of damage in case of collision of any description.

9. A ship may speedily be brought up by it, and ride with very short cable; the steadying power being at the crown end, it is of no object if the shank is raised off the ground, which stocked anchors will not allow.

10. In shallow water no damage can occur to a ship's bottom, as no part of the anchor projects above ground.

11. It is at least one-third shorter than ordinary anchors, therefore soon clear of the water, and more convenient to manage.

12. It can readily be disconnected, thus convenient to stow and easy to transport in case of need, its heaviest part being less than one-third its total weight.

13. It is made without welding, thus of great soundness.

14. It is worked with only one davit (being hoisted and let go by the fish shackle), therefore considering the saving of first cost and future maintenance of one davit and blocks, &c., it is by far the cheapest anchor to use, besides greatest safety and simplicity in working.

15. It is not dangerous when at "wash," for in the event of a collision, the arms would simply be flattened to the ship's side instead of being driven in.

16. Should the anchor be difficult or dangerous to weigh, from having got fast in rock or wreckage, a runner with messenger attached may be slipped down the cable to the crown end, and by this means the anchor can be drawn out freely, as there are no barbs or palms to retard it.

17. Being of such greater strength and holding power, and requiring less cable than other anchors, shorter and stronger cables may be carried, thus increasing the safety of the ship without additional weight or cost.

2178ha. Tube connections (Roots' Patent) for Water Tube Boilers, for use on land. The Patent Steam Boiler Company, Birmingham. *J. F. Flannery.*

2178hb. Full sized representations of the Tube connections (Roots' Patent) of the Water Tube Boilers, fitted in the screw steamer "Malta," of Liverpool, 1869. The Patent Steam Boiler Company, Birmingham. *J. F. Flannery.*

2178hc. Full sized representations of the Tube connections (Roots' Patent) of the Water Tube Boilers, fitted in the Mersey ferry steamer "Birkenhead," 1872. The Patent Steam Boiler Company, Birmingham. *J. F. Flannery.*

2178hd. Drawings (7) representing Sections of Water Tube Boilers, fitted by the Patent Steam Boiler Company, Birmingham. *J. F. Flannery.*

a. Ordinary water tube boiler on Roots' system.
b. Sections and elevations (2) of the water tube boilers in the Mersey ferry steamer "Birkenhead."
c. Water tube boilers fitted in the screw steamer "Montana."
d. Elevation and section of the water tube boilers fitted in the screw steamer "Propantis."
e. Sections of the water tube boilers of the steam flat "Gertrude."
f. Drawings of Wigsell's patent water tube marine steam boilers.

2178he. Models of a Water Tube Boiler and improved Steam Engine. *T. Moy.*

2178hf. Drawings of the High Pressure Tubular Boilers of the paddle-wheel steam yacht "Galatea." Front and end elevations. Section through firing end. Cross section. Plan.

Nominal horse-power, 200. Scale of drawing, 1 inch to 1 foot. Heating surface of two boilers of ship, 308 square feet; fire-grate surface, 186 square feet. Water space, 1,392 cubic feet. Steam space, 732 cubic feet. *William Willis.*

These drawings represent reproductions of the originals by Willis' Aniline Process. Executed by Vincent Brooks & Co.

2178hg. Drawing of Compound Marine Screw Engines. Side elevation and end elevation. *J. Dickinson.*

2178hh. Drawing of Dickinson and Mace's Patent Marine and Land Boilers. *J. Dickinson.*

Two mid-sections; front and longitudinal elevation. Sectional plans.

2178hi. Drawing representing proposals by Messrs. E. J. Reed, C.B., and W. Wimshurst, for a method of lowering and raising the screw propeller at ship's stern to suit her variable draft of water, and to avoid "racing" of the engines. *J. F. Flannery.*

2178hj. Model and Drawings of improved Water Tube Marine Steam Boilers. *E. Wigsell.*

2178hk. Willan's Patent Three Cylinder High Speed Engine for steam launches. *Hunter & English.*

2178hl. Steam Launch Screw Propeller for the three cylinder engine. *Hunter & English.*

The three cylinders are placed side by side. The three pistons work on to three cranks on the shaft set at angles of about 120°. Each cylinder is single-acting the steam acting on the top only of each piston.

The connecting rods are jointed at one end to the pistons, at the other end to the cranks on the shaft.

Each piston acts as a steam valve, by which steam is supplied to one of the other pistons. On the return stroke of the pistons towards the top of the cylinder, the lower part in the cylinder is uncovered to allow the steam to pass back out of the cylinder into the casing surrounding the crank shaft.

2178hm. Small size High Pressure Quick Speed Three Cylinder Horizontal Engine for screw launches, P. Brotherhood's patent. *Brotherhood & Hardingham.*

2178hn. Models of Hirsch's Screw Propellers as fitted to H.M.S. "Minotaur," and SS. "Pereine," French Atlantic service. *H. Hirsch.*

2178ho. Four block Models of the "Hirsch" Ship (Patent) illustrating the "Hirsch" principles of shipbuilding.

Hermann Hirsch.

The SS. "Paun-ting" was built on Mr. Hirsch's principle, by Messrs. John Elder & Co. for Paul S. Forbes, Esq., New York, in 1873.

Dimensions of SS. "Paun-ting."

Length between perpendiculars, 210 feet.
Breadth, moulded, 33 feet.
Depth, moulded, 22 feet 9 inches.
Draught on trial, 12′ 8″ forward, 13′ 9″ aft, 13 feet 2½ inches.
Displacement, 1,520 tons.
Mid-area, 392·2 feet.
Immersed surface, 12,344 feet.
Area of immersed midship section, 5,239 feet.
Displacement per inch, 12·4 tons.
Co-efficient of displacement, ·568.
Weight of hull and machinery, 790 tons.
Weights on board, 730 tons.
Maximum of Ind. H.P. 800.

Result.

Speed 11 knots.
Displacement co-efficient of performance, 220.
Mid-area co-efficient of performance, 652.

The Hirsch Ship (Patent).

CALCULATIONS and PRINCIPAL DIMENSIONS of SHIPS as per Models.

—	Mail Steamer.	Cargo. Steamer.
	ft. ins.	ft. in.
Length between perpendiculars	500 0	450 0
„ of keel for tonnage	470 0	414 0
Breadth extreme and for tonnage	50 0	60 0
Depth moulded to gunwale	37 0	38 0
Tonnage B. O. M.	6,250	$7,927\frac{62}{94}$
	ft. ins.	ft. in.
Draught of water forward	21 0	20 0
aft	21 0	20 0
Displacement in tons	8304·8	8221·22
Area of midship section in sq. feet	948	1091·3
„ loadwater line „ „	18304·166	19,602·4
Tons per inch immersion	43·58	46·67
Estimated weight of hull and machinery	4,300	4,410
„ „ cargo and coals	4004·8	3,811
Indicated H.P.	5,200	5,200
Estimated speed in knots	17	16
Co-efficient of fineness	·550	·527
Displacement coefficient of performance	387	321
Mid-section „ „ „	895	859·4
Metacentre above centre of buoyancy	10·024	16·154
„ „ water line	1·520	8·151
Centre of buoyancy below water line	8·504	8·003

2178hp. Photograph of the Twin Hull Passenger Steamer "Prinzessin Charlotte," built near Spandau, 1816.
G. P. Rubie.

This was a double hull or twin steamer. She had an engine of 14 horse-power, built by J. B. Humphreys, engineer, which drove one paddle-wheel between the hulls. Dimensions were, length, 130 feet 5 inches; width, 19 feet 4 inches; tons B.M. 236. The steamer was built by John Rubie, naval architect, and began to run on the Elbe, November 1816. The Photograph represents the steamer lying at "die Zelten" near Berlin.

2178hq. Drawing, showing longitudinal section, upper and lower deck plans of the SS. "Gloria" and "Victoria," built by W. Doxford & Sons, Sunderland.
Length, 320 feet.
Breadth, extreme, 38 feet.
Hold, depth to top of floors, 31 feet.
Scale, $\frac{1}{3}$ inch to 1 foot.
W. Doxford & Sons.

2178hr. Drawing, showing elevation and sail draft, longitudinal section and upper deck plan of the iron sailing ship "Delscey," built by W. Doxford & Sons. *W. Doxford & Sons.*

2178hs. Drawing, showing longitudinal section and upper deck plan of Her Majesty's gunboats "Cygnet," "Express" and "Contest," built by W. Doxford & Sons.
Scale, $\frac{1}{4}$ inch to 1 foot. *W. Doxford & Sons.*

2178ht. Drawing, showing longitudinal section and upper deck plan of SS. "Autocrat," built by W. Doxford & Sons.
Scale, $\frac{1}{8}$ inch to 1 foot. *W. Doxford & Sons.*

2178hu. Model of the Paddle Steamer "Aloungpyah," built for the navigation of river Irrawaddy in Burmah.
Length, 245 feet.
Breadth, 26 feet.
Depth, 8 feet.
Engines, compound diagonal, 150 horse-power.
R. Duncan & Co.

The model represents one of a fleet of steamers of the same type belonging to the "Irrawaddy Flotilla Company," which are used for the general traffic of the river Irrawaddy from Rangoon, in British Burmah, to Bhamo, in Upper Burmah, near the frontier of China, the whole distance by river being nearly 1,000 miles.

Each steamer carries light goods and passengers, and takes in tow two iron barges each 190 feet long and carrying from 300 to 500 tons weight of general cargo according to the season. In the dry season the river is very shallow in many parts, and in the wet season the current is very strong; the vessels have therefore to be all of very light draft and great power.

The "Aloungpyah" is 245 feet in length, 26 feet in breadth, and 8 feet in depth of hull. Above the main deck, raised upon iron stanchions as shown, there is a light passenger deck and small cabin, and above that again, on a continuation of the same stanchions, a light galvanized iron roof, watertight, under which a canvas awning is stretched to intercept the heat, and curtains along the sides for the same purpose. With the exception of the upper passenger deck and small cabins shown, the whole structure is of iron, so arranged as to give the greatest strength with the least material.

The engines are compound, diagonal, of 150 nominal horse-power, with two cylinders 31 and 54 inches diameter by 54 inches stroke.

Two boilers, cylindrical, tubular, horizontal, carrying a working pressure of 70 lbs. per square inch.

The coal bunkers on both sides of the engine and boiler space have capacity for 100 tons of coal, which in practice is found sufficient for the voyage from Rangoon to Mandalay and back, a distance of 1,400 miles, with two barges in tow lashed one on each side, and loaded as stated.

2178hv. Model of the Composite Sailing Ships "James Nichol Fleming" and "Otago," showing framework of composite ships of 1000 tons register. Built 1869.

R. Duncan & Co.

The model is intended to show the arrangement of the framework of a composite sailing ship of 1,000 tons register, and of the highest class at Lloyd's. The keel, stem, sternpost, rudder, and planking are of wood.

The frames, floors, beams, keelsons, stringers, and ties are of iron. The vertical black lines show the frames. The longitudinal and diagonal plates coloured blue show the outside ties on the frames, and the longitudinal black lines show the seams or edges of the planks.

The planking is put on outside of the frames and plate ties, and is bolted to the frames and plates by brass bolts and nuts, the seams are caulked with oakum, and then the whole wooden skin is sheathed with copper or yellow metal. The iron framework is intended to ensure the rigidity and strength of an iron ship, and the coppered bottom to ensure freedom from sea grass and barnacles, to which iron ships are subject on long sea voyages.

Whole Model, full-rigged, of the Sailing Ship "Lanoma." Built at Sunderland, 1876, for Thos. B. Walker, Esq., London. Length 185 feet, breadth 31 feet, depth 18 feet; tons, 665 register. *Austin and Hunter.*

The ship is barque rigged, and is on her first voyage.

Whole Model of the Four-Masted Sailing Ship "Shakespeare." Built on the composite system, iron framing, with exterior wood planking, by Messrs. Short Brothers, for W. Adamson, Esq., 1876. The ship is intended for the Australian trade. *Short Brothers.*

This four-masted sailing ship is designed for the utmost speed. From a voyage made already by a sister ship to Australia, it is expected that the "Shakespeare" will average 55 days on the passage. She is already at sea on the first voyage.

The officers and crew are housed on the upper deck, leaving the hull entirely free for cargo carrying only.

The ship's dimensions are—

Length	278 feet.
Breadth	40 feet 2 inches.
Depth	24 feet.
Tons - - gross	1,814
,, - - nett	1,757
She is classed at Lloyd's	100 A 1.

Sectional Models (three in number), showing various methods carried out by Messrs. Short Brothers in building ships on the composite principle. *Short Brothers.*

Model No. 1 illustrates a method of diagonal bracing both for the framing and deck beams of composite vessels.

Model No. 2 illustrates a trial of filling in between the ship's frame with vertical iron plating.

Model No. 3 illustrates the iron framing of a composite ship with improved stringers for tying the framing, and carrying the beams.

2178hw. Photograph from a painting of the paddle steamer **"Iona,"** 1874, compared with the "Comet," the first steamer on the Clyde. *The Institute of Naval Architects.*

2178hx. Model of the "Shakespeare," a four-masted sailing ship, and three sections illustrating composite construction. *Messrs. Short Bros.*

2178xy. Set of Annual Reports and Proceedings of the Institution of Naval Architects, 1860 to 1875. *Institution of Naval Architects.*

2179. Model of **J. Ericsson's Screw Propeller Engines,** applied to the American and Swedish Monitors, patented in America in 1858.

H.M. Commissioners of Patents.

2180. Models of Screw Propellers.

The Council of King's College, London.

2167a. Peraon, for automatically fixing the course of a ship, and for use with the bathometer. *Dr. F. Schöpfleuthner, Vienna.*

This apparatus replaces the compass and tiller of a ship, as when it has once been arranged for a particular course the ship is compelled accurately to follow that course, at the same time that it enables any tacking or turning to be executed with great ease and precision. This peculiarly constructed compass is fitted with hand-wheel and vernier, and by means of it the whole ship can be directed as required. The declination-needle, of which the arc of oscillation is very small, turns between the two movable electrodes of an electrical battery, which on coming into contact with the magnetic needle control the movement either backwards or forwards of the admission valve of a steam or hydraulic motor. This acts on the steering-gear, and when that is turned to its extreme point (which only occurs in turning the ship) its cuts off the admission, so as to avoid breakage.

2167b. Bathometer, for submarine levelling with graphic registration on board the surveying vessel.
Dr. F. Schöpfleuthner, Vienna.

This instrument is used in submarine levelling, and for the construction of charts of the water-covered portions of the globe. When in use it is attached to the surveying ship by a cable running through an insulated copper tube. It is towed after the ship, and is connected with a registering apparatus on board in such a way that the portion of the sea bottom passed over is represented in profile. The principle on which it acts is that of the equilibrium between a closed volume of air, and the pressure of the column of water resting on it, and the registration is effected by means of an electric telegraph. When it is employed the course of the ship is fixed by the Peraon described above; in order that the instrument may not be damaged against the rocks on the ground it is provided with a separate horizontal rudder.

2167c. Apparatus for guarding against the **Stranding** of **Ships.** *Dr. F. Schöpfleuthner, Vienna.*

This apparatus is placed on the bow of the ship, or on a steam launch which moves several hundred metres in advance of the ship; it serves for warning against rocks, sand banks, or steep coasts, and generally is used when in unknown waters. The determination of the sounding is effected by means of a lead which is towed at about a depth of 30 metres under water, and which is connected with a free swinging pendulum in such a way that, as an alteration of the angle between the two, a needle makes contact on the respective side. A tell-tale shows the depth, and by means of a cable connected with the ship sets a signal apparatus in action. The latter is only used when the steam launch is sent out in advance.

2178be. Russian and Manilla Hemp Ropes, used in shipping, and galvanized iron wire ropes for ships' rigging, &c.
Thomas & William Smith.

Tarred Russian hemp ropes for ships' rigging, running gear, lanyard ropes, towlines, warps, bolt rope for binding sails, and hauling ropes.

White manilla hemp rope, for towlines, warps, running gear, point line, &c., &c.

Houseline and marline for serving rigging, signal halyards, log lines, lead lines.

Galvanized wire rope, for ships rigging, stays, &c., with specimens of the different modes of fitting shrouds and stays with deadeyes, thimbles, and sockets.

Galvanized hank to run on the stays, different sizes of seizing strand used in fitting wire rigging, lanyard, and shackle thimbles.

Copper wire rope lightning conductor, fitted with a thimble to pass over the copper rod when driven into masthead.

2178bea. Specimens of Iron Wire Rope, for ships' rigging. *Newall & Co.*

2178beb. Case of Samples of Canvas Sail Cloth, for naval and commercial purposes. *Baxter Brothers.*

2180a. Model of a Propeller for Ships.
S. F. Pichler, London.

2180b. Model of Bevis's Patent Feathering Screw Propeller. *Laird Brothers.*

Mr. R. R. Bevis, managing engineer to the firm of Messrs. Laird Brothers, of Birkenhead, in 1868 patented an arrangement for altering the pitch or feathering the blades of a screw propeller in a fore and aft direction, which claims to be a great advantage for screw steamers, making them faster and more handy when under sail alone, and when under steam and sail allowing of adjusting the pitch to obtain the best result. A screw propeller of the ordinary kind, whether fixed or revolving, is a heavy drag against speed and handiness for sailing, and "lifting" it is a laborious operation, and requires a large hole or well through the ship's counter to admit of so doing.

The arrangement of this new screw propeller is free from many of the objections which have been made to feathering screws previously tried. The gear for feathering the blades is well protected, the levers and other gear that move the blades being enclosed within the boss of the screw propeller, and attached to a rod passing through the centre of the shaft, which is worked in the screw shaft tunnel. This system is admirably adapted for ships of war or sailing ships with auxiliary power or yachts, where it is as important to have a good result under sail alone as under steam. The operation of altering the pitch, or of feathering the blades to any angle, is done in a few minutes, without in any way putting the engines into a position that they may not be used in an emergency.

This feathering propeller has now been successfully tried in 15 vessels, and is at present being fitted to four vessels of H.M. Navy, one of them of 2,100 ind. horse-power.

2180c. First Helmet made for Diving Purposes, date A.D. 1829. *Siebe and Gorman.*

2180d. Patent Helmet for Diving, fitted with segmental neck ring and safety locking arrangement, inflating valve for bringing diver to the surface. Fitted with speaking apparatus to enable the diver to communicate with his attendant. Used on board H.M. Ships of the Royal Navy. *Siebe and Gorman.*

2180e. Diving Spectacles, fitted with air-lenses, having a focus in water of 1½ inch, for subaqueous vision.

R. E. Dudgeon, M.D.

The air-lenses are prepared from two sections of a thin glass globe 1½ inch in diameter, fixed in a spectacle frame with their convexities towards one another, and their concavities outwards. Under water these spectacles have a focus of 1½ inch, and supply the refractive power lost by the eye when submersed in water, owing to the aqueous humour which forms the anterior lens of the eye having the same index of refraction as water. Exhibited in the International Exhibition of 1871.

2180f. Boat moved by A. H. Garrod's Undulating Propeller. *H. C. Ahrbecker.*

This model is moved by an undulating propeller, of which the component staves (which carry the undulating membrane) successively receive their transverse motion from the rotation of a screw with which they are in lateral contact.

Invented by A. H. Garrod, in imitation of the undulating propelling fins of the pipe fish and sea horses.

X.—LIGHTHOUSES AND FOG SIGNALS.

2181. Model of a **Lighthouse** built upon the **Bishop Rock,** 7 miles from land, forming part of the outermost reef S.W. of the Scilly Islands. *Trinity House, London.*

The tower is of Cornish granite (Carnsew), and is surmounted by a lantern of gun-metal, containing lenticular apparatus to exhibit a fixed light of the first order, whose focal plane is 110 feet above high-water spring tides. The structure measures from base to vane 147 feet. It was built from designs by the late James Walker, M.I.C.E., under the superintendence of Nicholas Douglass, for the Corporation of Trinity House, London, at a cost of 36,500*l.*, and occupied six years in construction; it was completed in 1853. A sectional drawing shows the method of bracing by vertical and radiating wrought-iron ties, lately adopted for strengthening the structure.

2181a. Model of the Old Lighthouse on the Smalls Rocks, about 17 miles off the coast of Pembrokeshire. Erected 1776; replaced in 1861 by a stone lighthouse. The model is made out of one of the oak pillars of the original lighthouse. —Executors of the late Captain Pickering Clarke, R.N. *South Kensington Museum.*

2181b. Model of the Lighthouse on the Needles Rocks, Isle of Wight. Built 1857–1858. Light shown 1 January 1859.—Trinity House, London. *South Kensington Museum.*

2181c. Model of the Gunfleet Lighthouse. Iron. Built on Mitchell's patent screw piles, of which a model is also shown. The piles screw 40 ft. into the sand, and have screws 4 ft. in diameter. James Walker, engineer.—The Trinity House. *South Kensington Museum.*

2181d. Series of Models, illustrating mark buoys, used by the Trinity House Corporation round the British coast.—The Trinity House. *South Kensington Museum.*

2181e. Harbour Light. Chance's patent dioptric lens of the fourth order, for fixed light.—Chance Brothers and Company, Glass Works, Birmingham. *South Kensington Museum.*

2181f. Babbage's occulting Light Apparatus. Designed by the late Charles Babbage, F.R.S., for distinguishing lighthouses from one another by numbers.

It is adapted in the Exhibition to a dioptric light exhibited by Messrs. Chance. *Major-General Babbage.*

The system of occulting lights for distinguishing lighthouses from one another by numbers was invented by the late Charles Babbage about the year 1850. It was published in "The Exposition of 1851," and was favourably reported on by the Lighthouse Board of the United States in January 1852. It was subsequently published in the "Times" of Wednesday, July 11th, 1855, and elsewhere. It is capable of being introduced into existing lighthouses without disturbing the existing lenses, &c., and can be adapted to any single lighthouse without interfering with the adjacent ones. The number here shown is 587, thus :

The light is visible during a long interval; five occultations are made :

The light is then visible during a short interval ; eight occultations are made :

The light is then visible during a short interval; seven occultations are made :

The light is then visible again during the long interval as before, and the same series is repeated continually from sunset to sunrise : thus the seaman by counting the occultations becomes at once aware of the number of the lighthouse, and knows from his chart his exact position.

The lighthouses along the coast would, of course, not be numbered consecutively ; in fact, no two adjacent lighthouses could have numbers containing the same digit : for example, the lighthouses on either side of No. 587 might be 839, 614, 587, 293, 418, so that a mistake could not occur in identifying any one of them from the others.

2182. **Model** of a **Lighthouse** now building upon the **Little Basses Rock,** part of a reef about 7 miles S.S.E. of the coast of Ceylon. *Trinity House, London.*

The tower is of Scotch granite (Dalbeattie), each stone of which was dressed, fitted, and marked in this country, freighted to Galle, and thence carried to the rock and fixed in its place. The light is intended to be of the first order, dioptric, on the group-flashing principle, showing two flashes in quick succession every minute, at an elevation of 110 feet above high-water spring tides.

The rock is awash at low water, and is exposed to heavy seas during both the N.E. and S.W. monsoons, and while the latter prevails is inaccessible for work. The drawings show the methods of landing stone in a seaway by steam-power.

This lighthouse, as well as its fellow on the Great Basses just completed, is building from designs by James N. Douglass, M. Inst. C.E., under the superintendence of William Douglass, M. Inst. C.E., for the Corporation of Trinity House, London, acting on behalf of the Home and Colonial authorities.

Its cost is estimated at 73,000*l.*, and completion is anticipated within five years from date of commencement.

2182a. **Lantern and Apparatus intended for the Little Basses Lighthouse, Ceylon.** *Trinity House, London.*

The lantern is of the cylindrical type adopted by the Trinity House, its form gives maximum strength, and secures greater optical accuracy than the earlier methods of flat glazing. The gun-metal framing is inclined about 30° from the perpendicular, and is helically curved throughout, thus reducing to a minimum the obstruction offered to the light sent forth from the lenses.

The optical apparatus, constructed upon the group-flashing principle, designed by J. Hopkinson, B.A., D.Sc., at the glass works of Messrs. Chance Brothers, is the first dioptric instrument of its kind adopted by the British lighthouse authorities. It is 12-sided, and makes a completed revolution in six minutes, so that the panels being arranged in pairs, a double-flash meets the eye of the observer once a minute.

The lantern and apparatus prepared for this structure are exhibited in working order in the grounds outside the Museum.

2183. Drawing of a **Light Vessel** with deck plans showing internal arrangements and disposition of Syren **Fog Signal** machinery. *Trinity House, London.*

The hull is designed after that of the vessel now at South Sand Head (Goodwin), built last year, of about 212 tons, and fitted with a syren fog-signal, giving one blast every two minutes, by means of compressed air, at a pressure of 30 lbs. to the square inch, the apparatus being driven by a caloric engine, which also works the windlass.

The illuminating apparatus represents that in use at the Royal Sovereign Shoal, off the coast of Sussex; it is catoptric, and is upon the "group-flashing" principle, giving three flashes in quick succession every minute. The crew space is for seven men, including the officer in charge. The hollow iron mast affords access to the lantern, and allows of the lamps being trimmed in all weathers without danger of extinction.

2184. Two **Syrens,** each a portion of the present **First Class Fog Signal,** and a diagram showing the method by which they are put in action. *Trinity House, London.*

The disc syren, with the trumpet by which its sound is directed, is shown in the diagram. It is composed of a fixed disc, forming one end of the chamber into which steam or compressed air is forced, and a movable disc rotating rapidly by separate mechanism outside it. Both are perforated by 12 radial slits exactly corresponding each to each, and the rotation of the moving disc, close to and upon a common axis with its fixed associate, permits the compressed air or steam to escape when the slits coincide, and shuts it off when they do not. The vibrations thus produced being repeated in the instrument described, at the rate of more than 400 per second, emit a sound of very great intensity, which is directed by the trumpet towards any desired point.

The cylindrical syren is a later form of the instrument, in which the chamber for compressed air surrounds a fixed cylinder having 24 slits, within which another cylinder coincidently perforated rotates, and the vibrations pass through the open end of the inner cylinder to the trumpet.

Syrens sounded by steam have for some time been used for fog-signalling on the coasts of America, and have lately been adopted, with the substitution of compressed air for steam, in Great Britain as a result of experiments made by the Trinity House with the assistance of Professor Tyndall during the winter of 1873.

2185. Fog Signal Apparatus. Designed by Dr. G. Amadi, of Trieste.

The Imperial and Royal Maritime Government at Trieste.

By this apparatus deep tones, like those of an organ, are produced by metallic tongues, driven by steam, and sent through a trumpet in a given direction. These, from experiments, have extended as far as 16 nautical, or nearly four German miles.

In working this apparatus, of which already three are in use, at Trieste, Salvore, and Grado, the sounds are made self-producing at certain intervals by means of a steam-engine.

2185a. Holmes' Shipwreck Distress Signal Flare and Life Buoy Rescue Lights. *N. J. Holmes.*

These have the remarkable property of bursting into flame when placed in contact with water, and when once ignited are absolutely inextinguishable by either wind or water. They emit a most powerful white light, as brilliant as the magnesium light, and continue to burn over 30 minutes. The shipwreck distress signal flare is visible on a dark night with a clear atmosphere at a sufficient elevation for over ten nautical miles, and burns with greater brilliancy the more seas sweep over it.

The light is a chemical light, and produced by the action of the water upon phosphuret of calcium, giving off phosphuret of hydrogen, which, combining with the oxygen in the atmosphere, spontaneously ignites. These distress signals are free from danger, are not affected by heat, friction, or percussion, and contain no explosive compound whatever.

2185b. Holmes' Mechanical Compound Reed Fog Horn. *N. J. Holmes.*

These mechanical fog alarms are constructed upon the most approved acoustical principles, and emit a most powerful sound. The "aurora" fog horn can be heard over three nautical miles, and the note produced is the 8 foot C of the musical scale. The tone is produced by the vibrations of two metal tongues, placed together in absolute contact, and closing the same reed, by which means (the split tongue) a powerful vibration is set up with a minimum pressure of air. The air bellows consist of two metal cylinders, one working inside the other; and the compressed air upon the return of the cylinder is driven through the reed into an inner trumpet-shaped tube contained within and a part of the external cylinder.

2185c. Drawing of the Steam Syren or Fog Horn, erected on the South Foreland, coast of Kent.
Prof. W. F. Barrett.

2186. Parabolic Reflector of 21-inch aperture.
Trinity House, London.

Composed of copper coated with pure silver in the proportion of 3 ozs. (troy) pure silver to 1 lb. (avoirdupois) copper. Its focal distance is 3 inches.

Improvements in the construction of light vessels' lanterns have permitted the introduction of this large sized reflector into that service, in which a 12-inch aperture had hitherto been the limit of size.

2187. Centrifugal Governor. A mechanical arrangement used for controlling the movements of the clockwork machinery, by means of which a light is made to revolve on board a light ship. *Trinity House, London.*

Before this contrivance was designed by Mr. Slight of the Trinity Workshops, there was always a tendency to irregularity in the periods of duration of the light and the interval of darkness, but the centrifugal governor ensures the working of the revolving machinery with very great accuracy.

2188. Improved Six-Concentric-wick Lamp, for burning vegetable or mineral oil. *Trinity House, London.*

The burner hitherto in use for dioptric apparatus of the first order has carried four concentric wicks, and in burning has been maintained at full power in all weathers. In the improved six-wick burner, designed by J. N. Douglass, M. Inst. C.E., only the three outer wicks are to be used in ordinary weather, and in thick weather the three inner wicks (at other times cut off by a concentric reflector) are also brought into action. The full light-producing power of the six-wick lamp is equal to 722 standard sperm candles, attained by a consumption of 1 gallon of oil in 1 hour 50 minutes; its half-power equals 342 candles, with 1 gallon consumed in 2 hours 45 minutes. By a simple arrangement regulating the level of oil in the burner, and the position of the air-deflectors, the lamp can be made to burn any description of oil at pleasure.

2189. Panel of **Cata-Dioptric Apparatus, One** of a set of **Polyzonal Lenses** manufactured in 1836 by Messrs. Cookson and Sons, of Newcastle, for the Trinity House of London, and by them fixed in the Start Point Lighthouse, Devonshire.

Trinity House, London.

The first lenticular apparatus used in an English lighthouse, with a central lamp upon Fresnel's principle.

2190. Plano-Convex Lens, used at Portland Lighthouse in the year 1789. *Trinity House, London.*

It is 22 inches in diameter, and was placed in front of an argand burner and reflector. It is believed to be one of the lenses first used in combination with an oil lamp and reflector for lighthouse illumination.

2191. Facet Reflector. Specimen of a reflector and lamp used first at Liverpool about the year 1763, and afterwards at Lowestoft and other lighthouses. *Trinity House, London.*

It is made of wood with facets of silvered glass, is nearly paraboloidal in form, and is the earliest kind of reflector known to have been used in aid of an oil lamp in lighthouse service.

2192. Lamp and **Reflector,** as used in English floating lights about the year 1809. The curve of the reflector is spherical.

Trinity House, London.

2193. Dhu Heartach Lighthouse, situated on a rock on the West Coast of Scotland, exposed to the force of the Atlantic Ocean, and 14 miles from Iona, the nearest land. Designed and executed by D. & T. Stevenson, Engineers to the Board. Commenced 1867, finished 1872.

The Commissioners of Northern Lighthouses.

2195. Model of a **First-class fixed Dioptric Light;** scale, one-fifth of full size.

The Commissioners of Northern Lighthouses.

This apparatus consists of a central lenticular band, and an upper and lower set of reflecting prisms. The cylindrical belt with diagonal joints and the upper and lower reflecting prisms were substituted by Mr. Alan Stevenson, in 1836, for the segmental belt, and upper and lower silvered mirrors of Fresnel's first-class apparatus.

2196. Model of **Fresnel Revolving Apparatus,** as made for Skerryvore Lighthouse in 1843 ; scale, one-fifth of full size.

The Commissioners of Northern Lighthouses.

The light is received and collected into eight horizontal beams by the principal lenses—the light which would escape above is collected into eight inclined beams by small lenses, and reflected to the horizon by inclined mirrors. The lower part of the light is sent equally to all parts of the horizon by prismatic rings of glass, which act as mirrors. The rings at Skerryvore are the first that were made of the largest or first order size, and were undertaken by M. Soleil, on the proposal of Mr. Alan Stevenson.

2197. Model of **Stevenson's Holophotal Revolving Apparatus ;** scale, one-fifth of full size.

The Commissioners of Northern Lighthouses.

The central part of this apparatus consists of eight of Fresnel's lenses. The light which passes above and below these lenses is collected into eight horizontal beams by reflecting prisms. These reflecting prisms were substituted for the inclined lenses and mirrors of Fresnel's first-class revolving apparatus by Mr. Thomas Stevenson, and were first used by him at Singapore, in 1849, on a small scale, and adopted on a large scale at North Ronaldshay, in Orkney, in 1851.

2198. Stevenson's Dioptric Holophote.

The Commissioners of Northern Lighthouses.

This apparatus collects all the light of the lamp into one beam of parallel rays solely by means of glass. The apparatus constituting the front half of the instrument bends the light that falls upon it into a beam of parallel rays, while the prisms which constitute the back half are so formed as to prevent any light from passing through, and to cause every ray to return back to the flame, and to be finally transmitted through the front half, so as to increase the intensity of the emergent beam. A large red ball is fixed on a rod, so as to be in focus, to illustrate the action of the instrument. To an observer, the front half of the apparatus will appear full of red light, but in the back half no red is to be seen, though the lower part of the rod which carries the ball, not being in focus, is distinctly visible.

2199. Stevenson's Fixed Azimuthal Condensing Light. As used at the leading lights of the River Tay.

The Commissioners of Northern Lighthouses.

It is remarkable from its employing every kind of dioptric apparatus. The whole of the light coming from the flame is spread equally over a horizontal arc of 45° by means of the following instruments ; viz., Fresnel's fixed-light apparatus and annular lens, and Mr. T. Stevenson's condensing prisms, holophote, right-angled conoidal prisms, and dioptric spherical mirror, with Mr. J. T. Chance's setting.

2200. Model of **Stevenson's Apparent Light.**

The Commissioners of Northern Lighthouses.

A beam of light, projected on the apparatus in the lantern on the beacon from a lighthouse on the shore, is reflected or refracted in such a manner as to indicate the position of the beacon at night. It was first used at Stornoway, in Scotland, in 1852.

2201. Model of the **Lamlash Lighthouse Apparatus,** showing the new twin prisms for preventing the loss of light by absorption, and for saving room in the lighthouse, lately described by Mr. Thomas Stevenson in "Nature," which are now for the first time being constructed, and the new back prisms first introduced at Lochindaal Lighthouse, in Islay in 1869.

The Commissioners of Northern Lighthouses.

2201a. Revolving Light, with Fresnel Apparatus, condensing lenses, and electric lamp, 1876.

Sautter, Lemonnier, & Co., Paris.

It is proposed to use this light on Cape Grisnez, near Calais.

2201b. Catadioptric Light, with "projector" apparatus and electric lamp, 1876. *Sautter, Lemonnier, & Co., Paris.*

This apparatus is designed to throw or "project" a flash of light seaward at certain intervals of time, or at will. It is fitted with mechanism for the purpose of varying the altitude and azimuth of the beam of light projected towards the sea, so as to ensure the utmost effect in all states of the atmosphere.

2202. Lighthouse Apparatus.

1. Lens with échelons. 1st essay. Fresnel, inventor, 1819.
2. Polygonal lens, of the first order. Do. do. 1820.
3. Annular lens, of the first order. Do. do. 1821.
4. Apparatus for fixed lights. Do. do. 1824.
5. Apparatus with catadioptric rings. Do. do. 1825.
6. Lens with catadioptric rings, constructed in . 1825.
7. Model of apparatus with catadioptric rings. Fresnel, 1825.
8. Burner with 4 wicks, constructed after experiments made by Arago and Fresnel in . . . 1820.
9. Burner with 2 wicks, with external covering, by Henry-Lepaute . . . . . 1845.
10. Burner with 4 wicks, storied, for mineral oils.
11. Large annular lens of Barbier and Tenestre . 1867.
12. Lenticular panel for flashing lights of Henry-Lepaute 1876.
13. Apparatus for revolving electric lights, of Sautter, Lemonnier, & Co. . . . . 1876.

Lighthouse Service of France, Paris.

Echeloned Lenses.

No. 1. First essay of echeloned lens, polygonal form. Invented by A. Fresnel, and constructed under his direction in 1819.

No. 2. First echeloned lens, polygonal form, for flashing lights of the first class. Invented by A. Fresnel, and constructed in 1820.

No. 3. First echeloned lens, annular form, for flashing lights of the first class. Invented by A. Fresnel, and proceeding from the lenticular apparatus fixed on the tower of Cordouan in 1821.

When Fresnel conceived the idea of substituting in lighthouses large glass lenses for metallic reflectors, he thought of composing these lenses of several pieces, and of calculating the curves of these different pieces so as to rectify their spherical divergence. He demonstrated his plan before the Lighthouse Committee in August 1819, three months only after his appointment on the Committee, and on the 19th of October following he was granted the sum of 500 fr. for constructing a trial lens. He consulted the optician Soleil, who seconded him with much good will, but who could only put at his disposal the limited appliances then in use. Glass was at this time worked still by hand, and shaped only into plane or spherical forms. Fresnel admitted that the lens should be flat on one side; that the different gradients, instead of forming circular rings, should be defined by polygons and divided into a certain number of pieces, each of which should receive on its echeloned side a spherical surface properly calculated. Another difficulty arose from the glass factories being unable to supply in sufficient size pieces of crown glass free from bubbles and striæ; but M. Soleil discovered the way of re-smelting glass without altering its transparency.

He first constructed a trial lens of 35 centimetres diameter (the one exhibited under No. 1). It was given by Soleil to the Academy of Sciences, and deposited at the "Conservatoire des Arts et Métiers." It is composed of 21 pieces, cemented together, and fixed upon a pane serving as a support.

Emboldened by this first success, Fresnel proposed to the Lighthouse Committee, at their sitting of 31st December 1820, to order the construction of a lenticular revolving light apparatus for the Cordouan lighthouse. The principal part of this apparatus was to include eight square lenses of 76 centimetres, forming together an octagonal prism inscribed within a cylinder of 2^m diameter. This proposal was adopted, and M. Soleil undertook the construction of these eight polygonal echeloned lenses. (One of them is exhibited under No. 2.) It is to be seen that it was composed of 100 pieces of glass, cemented together, and that the flat pane, which in the trial lens serves as a support, has been done away with. One of these new lenses was first tried in public on 13th April 1821. It was placed on the top of the Observatory buildings, together with two large reflectors, one by Lenoir, the other by Bordier-Marcet. The Lighthouse Committee, of which Mr. Becquey, director-general of the "Ponts et Chaussées," was chairman, went to the summit of Montmartre to judge of the effect. The result confirmed the inventor's previsions, and every one allowed the superiority of the lens over the reflectors. Meanwhile, Fresnel had already thought of improving these first essays. He had invented a machine for constructing circular rings, and M. Soleil was instructed to make eight large lenses constructed on annular principles. He soon finished some of them, and in September 1821 the Lighthouse Committee determined to try their effect at long distances. Fresnel had fitted up on the top of the "Arc de l'Etoile" a revolving apparatus upon which were fixed two of these annular lenses, four polygonal lenses previously constructed, and four semi-polygonal lenses. At the focus, a four-wicked lamp was burning. The committee then went to Chatenay, a village situated N.N.E. of Paris, 24½ kilometres distance from the "Arc de l'Etoile." The experiment took place during the night of 7/8 September 1821, and the results were adjudged as very satisfactory. The eight annular lenses that had just been constructed form part of the first flashing-light apparatus of the 1st class that Fresnel himself fixed on the watch-tower of Cordouan, and which has lighted the entrance to the Gironde for more than 30 years. (The lens exhibited under No. 3 comes from this apparatus.)

If an idea is to be formed of the progress made in the science of lenticular lighthouses from its origin to later times, the three lenses before mentioned should be compared with the lenses of modern construction exhibited under Nos. 11, 12, and 13.

Fixed Light Apparatus.

No. 4. First fixed light apparatus of $0{\cdot}50^{m}$ diameter, invented by A. Fresnel, and constructed in 1824.

Fresnel, after his appointment to the Lighthouse Committee of 1819, first gave his attention to flashing lights ; meanwhile, he had thought about obtaining fixed lights, and in the first design of the lenticular lighthouse that he submitted to the committee on 31st October 1820, he indicated, as a solution, the use of cylindrical lenses ; but the Lighthouse Committee had thrown aside the fixed light system as possessing less power than revolving lights, and as being liable to be mistaken for the incidental lights of the coast. The committee altered this decision later, and Fresnel then invented the system of fixed light apparatus (0.50^{m} diameter), exhibited under No. 3. In this apparatus the lenticular drum, which should be cylindrical, so as to give an uniform subdivision of light, shows a polygonal form of 16 fascets, because no lathe was then known for making cylindrical pieces. The upper part is made up of two lenticular zones in the shape of a 16-panel cupola, every element of which is coupled with a plane mirror. The lenses unite in parallel fasces the rays emitted by the light, and the mirrors reflect them in the direction of the horizon.

A similar system, but having one lenticular zone only, is fitted at the lower part. The lamp has two wicks, and stands upon a plate raised or lowered by a jack between three leaders. With the polygonal form that had to be adopted, there were 16 directly receiving more light than the intermediate parts, but Fresnel, while constructing the instrument, discovered the means of greatly lessening this inequality, by alternating the shining directions of the lenticular cylinders with those of the two other parts. This first trial of a fixed light apparatus was demonstrated by Fresnel before the Academy of Sciences of Paris, at their sittings of 3rd May 1824. It was then inaugurated on the 1st February 1825 in the port of Dunkirk.

Catadioptric Rings.

No. 5. First apparatus containing catadioptric rings, as well for fixed light as for flashing lights, invented by A. Fresnel, for lighting the St. Martin Canal, and constructed in 1825.

No. 6. Annular lens, composed of dioptric and catadioptric elements, similar to those of apparatus No. 5, and constructed at the same date.

No. 7. Models in wood of an apparatus similar to No. 5, but on a larger scale. Researches of A. Fresnel in 1825.

The last invention of A. Fresnel, that of the catadioptric rings, was promoted by a request for information addressed to him by the Prefect of the Seine in 1825. It was a question of applying to the lighting the quays of the St. Martin's Canal more powerful lamps than those used commonly in the city of Paris. This problem, to which Fresnel's attention was called, was the same as that of the port-lights apparatus, of which he had postponed the study because the sidereal reflectors of Bordier-Marcet were sufficient to supply the wants of the service.*

The principal part of these small apparatus, that is, the lenticular cylinder, offered no theoretical difficulty. It was to proceed out of an echeloned section turning around the vertical axis ; the only thing was to construct it in circular shape, because the polygonal shape would have been impossible for rings of 20 to 25 centimetres diameter. The question was not so easily solved as regards the accessory parts intended to utilise the luminous rays passing outside the cylinder, because the reflectors used in the other classes must now be reduced to too small dimensions. It was then that Fresnel thought of the phenomenon known in optics under the name of "total reflection," and proposed to substitute for the common reflectors glass rings, within which the luminous rays should be reflected without appreciable loss.

Fresnel's first conception for these circular rings was to place the fascets through which the luminous rays pass perpendicularly to these rays, so as not to alter their direction; the reflecting surface would then have preserved the shape of the mirrors to be replaced, but hence resulted inconvenience, and a too great weight of glass. Fresnel found out that a direction inclined to the rays could be given to the fascets, and thus these inclinations be combined, as well as the shape of the reflecting surface, so as to cause the rays to emerge horizontally. The transverse section of the rings then became triangular, instead of showing four sides, and the dimensions were reduced.

The apparatus exhibited is that to which Fresnel first applied this invention. Its diameter is reduced to $0{\cdot}20^{m}$; the cylinder is generated by an echeloned section composed of three elements and fills up a half circumference. The rays passing above this cylinder are gathered by four total reflection rings, and this is effected by turning around the vertical point of the focus the section of the catadioptric triangles just spoken of. Thus is obtained a fixed light apparatus, lighting up half the horizon. The lamps of the St. Martin's Canal having to be erected at 70 metres distance, it became necessary to give them a greater lateral than frontal intenseness. Fresnel succeeded in this by placing on each side a half annular dioptric lens, generated by the rotation of the section of the cylinder around an horizontal axis, parallel with the longitudinal direction of the quay, but he had moreover the happy idea of making the section of catadioptric triangles to revolve around this axis so as to form an annular lens, collecting around the focus an angle of great amplitude, and comprising at the same time dioptric and catadioptric rings.

The manufacture of these different circular rings offered serious difficulty, and Fresnel was obliged to set up a factory.

A first apparatus was completed in 1826, and submitted to the Lighthouse Committee towards the end of December. Four of these new lamps were finished at the beginning of 1827, but they could not be tried until after the inventor's death.

This study shows how Fresnel came to invent not only the section of catadioptric rings, and the use of these rings in fixed light apparatus, but also to apply them to annular lenses for flashing lights or for fixed lights. By uniting the pieces of dioptric elements and of catadioptric rings manufactured in Fresnel's time for the apparatus of the St. Martin's Canal, the annular lens exhibited under No. 6 was formed, and it may be considered as the type of all the annular lenses used in the lighthouses of different order.

The model in wood, No. 7, represents an apparatus similar to the preceding, but having a diameter of $0{\cdot}25^{m}$ instead of $0{\cdot}20^{m}$. It is a study of Fresnel's which he did not carry out.

Lamp Burners.

No. 8. One of the first burners, with four concentric wicks, constructed after experiments made by Arago and Fresnel in 1819–20.

No. 9. Burner, with two wicks and outer casing for directing the draught, constructed by Henry-Lepaute in 1845.

No. 10. Burner, with five wicks, of graduated shape, for mineral oil, with the last improvements adopted in the lighthouses of France, 1876.

When Fresnel undertook the improvement of lighthouses, he had to solve not only the problem of construction of the lenses, but also that of lamps with several wicks. The chemist Guyton-Morvau had already studied the question. In a paper read by him at the Institute in 1797, he stated that he had constructed, 10 years before, a lamp on the Argand principle, with three concentric circular wicks, each having an inner and an outer draught. It gave great intensity, but the solderings of the burner were destroyed by the heat. About 1800, the watchmaker Carcel invented the lamp that bears his name, and in which the oil at the bottom is forced up by a pump towards the burner above which it overflows. This invention subsequently led to the solution of the problem of lamps with many wicks. Consequently, when Arago and Fresnel began, in 1819, their experiments with lamps, they forced up the burner oil in superabundance so as to replenish it, and thus avoid the inconvenience met with by Guyton-Morvau. The first trial took place in September 1819 with two-wicked and three-wicked burners, constructed after Fresnel's designs. After several deliberations, chiefly respecting the width to be adopted for the draught between the wicks, they succeeded in constructing a four-wicked burner that gave good results. It was tried 12th May 1820, in presence of the Lighthouse Committee. The burner exhibited under No. 8 is one of those that were constructed according to this first type.

The two-wick burner, No. 9, was constructed by Henry-Lepaute in 1845, for the lighthouse of Schevening in Holland. It has an outer cylinder for dividing the draught generated between the glass and the burner, and throwing back a part of it upon the light. It is the first application of this cylinder which exists in all modern burners.

The five-wick burner, No. 10, is a model of those now constructed for using mineral oil in the French lighthouses. It contains an appendage through which the oil must pass before reaching the upper part of the burner. This said piece, of which the arrangements were invented by M. Dénéchaux, acting engineer in ordinary at the lighthouse depôt, is intended to secure a continuous level, and comprises three tubes, juxtaposed, and open on the upper part at the proper height; the central tube springs from the small reservoir which forms the base of the burner, and in which the oil is forced by the machinery of the lamp; this oil, having no other exit, rises in the tube, and, arriving at the top, flows into the second tube, which carries it into the annular spaces containing the wicks; these it fills while keeping the same level as in the lateral appendage. As the quantity of oil forced up by the lamp is greater than the consumption, the excess comes down into the large reservoir of the lamp by flowing into the third tube over a fall rather higher than that cleared by the oil in reaching the burner. A horizontal disk of 20 millimetres diameter rises, at the height of 21 millimetres, above the central draught tube, and an outer cylinder divides in two the draught created between the burner and the glass. It is upon this outer cylinder that the glass-holder stands. In this burner the empty spaces between the wicks, intended for air passages, are 5½ millimetres wide, while the spaces that contain the wicks are only 4½ mill. In the burners constructed up to the present time, both widths are of 5 mill.; this new arrangement seems to give better results. The burner has, besides, on its upper part, a graduated shape, so that each wick is placed about 2 millimetres below the one which precedes it towards the centre. This arrangement, as yet adopted only for the Pilier lighthouse, exhibited under No. 12, has been found necessary since the burners, in each order of lighthouses, have had one burner added to them, and therefore are wider. Its object is to lower the edge of the burner, in reference to the centre of the light, so as to reduce as much as possible the portion of light obscured by this edge in the lower part of the lenses. (*See* description of apparatus, No. 12.)

Modern Apparatus.

No. 11. Great annular lens, of the first order, 1·10^{m} in diameter, Messrs. Barbier and Fenestre, constructors, 1867. This lens was constructed by Messrs.

Barbier and Fenestre as a specimen of high class workmanship. Each ring is one single piece; the joints which divide the rings are inclined according to the direction of the refracted ray. The lens is mounted on a pedestal, and revolves around any horizontal axis.

No. 12. Lenticular panel, dioptric and catadioptric, for flashing lights of the second class, planned by the head engineer, Allard, and constructed by M. Henry-Lepaute, 1876.

This panel forms part of an apparatus intended for the Pilier lighthouse, situated at the mouth of the Loire, and of which the tower has just been rebuilt. The character given to it in 1829 has been preserved; it is a fixed light varied by flashes every four minutes To produce this character a fixed light apparatus has been adopted, of which two sectors of $\frac{1}{8}$th horizon, opposed to one another, are replaced by perfect annular lenses; it revolves at the rate of one turn in eight minutes. In order that the two kinds of lenses may be adjusted upon the edges, and have a common pinion-jack, the focal distance, which is $0{\cdot}700^{m}$ for the fixed lenses, has been reduced to $0{\cdot}647^{m}$ for the annular lenses. The focal lamp has five concentric wicks, instead of four, as usual in lamps of the second class, because the light, being coloured red in certain directions, it was thought necessary to increase its intensity.

This panel shows several novel arrangements, some of which are now applied for the first time.

1st. In the central or dioptric parts of the section, the joints that divide the elements, and therefore the lower sides of these elements, instead of being horizontal, are inclined according to the direction of the refracted ray. This system has several advantages: it does away with a triangular part of glass which is useless, and thus lessens the weight of the apparatus; it reduces in a large proportion the loss of light caused by horizontal joints; it makes less acute, and consequently less fragile, the outer angles of the elements, and, besides, it diminishes their projection, thus enabling the dioptric lens to have a greater height.

2nd. The central lens (or dioptric) comprehends a vertical angle of 76 degrees, whereas, in the old sections, this angle was of about 60 degrees only; its elevation is thus increased from $0{\cdot}85^{m}$ to $1{\cdot}10^{m}$. This advantage is thus obtained, that the luminous rays meet the last dioptric element at the same angle as the first catadioptric ring, and suffer no more loss of reflection upon the one than upon the other.

3rd. The section commonly used in apparatus of the second class had been calculated for a three-wick lamp burner of $0{\cdot}074^{m}$ diameter. With a five-wick burner of $0{\cdot}110^{m}$ diameter, the inferior elements of the dioptric lens and the lower catadioptric rings, constructed after this old section, emit rays that are no longer in the proper direction, because the portion of light which the base of the burner leaves visible becomes perceptibly nearer to the lens than in the case of a three-wick burner. To lessen this defect, a graduated shape was given to the burner, by placing each wick $0{\cdot}002^{m}$ below the one preceding it on the side of the centre. This arrangement reduces neither the regularity nor the intensity of the light, and the part of that light, visible from each of the lower lenticular elements, becomes somewhat increased. Moreover, these lower elements have been calculated by determining for each of them a particular focus taken on the brightest line of the apparent part of the light, instead of on the axis itself of the lamp. Similar arrangements might be advantageously adopted in many cases.

4th. The central lens and the lower rings are included in the same frame, the upper rings are set in a second frame, separated from the first by a metal cross-bar. In the annular lenses, this cross-bar takes the shape of the arc of a circle having, like the rings, its centre on the optical axis; the result is that the rings can remain intact, instead of having to be cut, as was the case until now.

5th. The lamp, placed at the focus of the lens exhibited, shows special arrangements, due to M. Dénéchaux.

Thus, the skin pockets or valvulæ, and the leathern valves, which are sometimes the cause of disorder, are replaced by ordinary pistons and metal valves. This system has produced good results in experiments made at the depôt, but it has not yet received practical sanction.

The lamp with five wicks for burning mineral oil has an intensity of 36 carcel burners, the fixed light apparatus produces an intensity of 640 burners, and the annular lenses of more than 5,000 burners.

No. 13. Apparatus for electric revolving light, constructed by Messrs. Sautter, Lemonnier, & Co., 1876.

This instrument is intended to produce, by electric light, a light revolving at intervals of 30 seconds. It includes a fixed light apparatus $0 \cdot 50^{m}$ diameter, lighting three-fourths of the horizon, around which revolves, in eight minutes, a tambour of $0 \cdot 62^{m}$ diameter, and composed of 16 vertical, lenticular elements.

In the section of the fixed light apparatus the central dioptric part subtends a vertical angle of 76 degrees, which is greater than in the old sections. This arrangement is adopted in order that the luminous ray may meet the last dioptric element at the same angle as the first catadioptric ring, and should suffer no more loss by reflection upon the one than upon the other. The apparatus having to be fixed on an elevated point, the section of the several parts, except that of the two lowest catadioptric rings, has been calculated so as to throw the focal line of the emergent rays, 30 minutes below the horizontal line; in the calculation of the two lowest rings, this angle is increased by three degrees for the last but one, and by five degrees for the last, so that the lighthouse may remain visible at a short distance, that is, by a navigator placed below the divergent cone emitted by the rest of the apparatus.

The sixteen vertical lenses are contiguous, and are each composed of a single element, about $0 \cdot 12^{m}$ wide, the curve of which has been calculated so as to give with the electric light an horizontal divergence of three degrees seven minutes. The duration of a flash is, accordingly, of about five seconds, and the interval between the end of a flash and the beginning of the following one is 25 seconds.

The maximum intensity of the flash rises to about 60,000 carcel burners, assuming at the focus an electric light of 200 burners power.

The electric light is produced in this apparatus, as in the lighthouses established on the coasts of France, by means of a Serrin regulator and an electrical machine of the Compagnie l'Alliance.

Experiments have been made with the Serrin regulator at the lighthouse depôt since the year 1860. A model on a large scale has been constructed especially for the lighthouse service, and has always given good results. The regulator exhibited is a counterpart of this model.

The electro-magnetic machine has been, as is well known, designed by MM. Nollet and Joseph Van Malderen, in accordance with the same principle as the scientific apparatus of Pixii and Clarke. It produces alternate currents, and, as it was in the first instance destined for the decomposition of water or for electro metallurgy, it was provided with a commutator for bringing the currents into one constant direction. When the question was raised of applying it to the production of light, M. Van Malderen, who had then become the mechanical engineer to the Compagnie l'Alliance, conceived the happy idea of suppressing the commutator, which is difficult to maintain, and has the effect of more or less weakening the current. The luminous intensity was found to be appreciably augmented, and the fact was soon acknowledged that alternate currents are, *cæteris paribus*, more favourable regulators than those in a constant direction. The machines of the Compagnie l'Alliance had originally six discs; these were reduced to four when the improvements introduced into the coils and the magnets permitted of a greater intensity being obtained with these smaller machines than with the former. In the case of lighthouses, where there cannot be too great intensity, the number of six discs has been preserved.

The central depôt in Paris has retained, since 1860, the first specimen constructed by M. Van Malderen of this machine, with the currents not brought into one constant direction. It has six discs, and carries 56 magnets; it is 1·63 metre high, and 1·43 metre in diameter; it gives less light than the present machines, but it works very well still, and serves for the experiments that are made at the depôt.

This first machine of the Compagnie l'Alliance may be regarded as the starting point of all the attempts which have since been made of economically transforming power into electricity, and consequently into light. On that account it is no more than right, although the machine is not included in the Exhibition, to make mention of it in the catalogue.

2203. The Original Model of the Eddystone Lighthouse.

The Eddystone Rocks, so named from the great variety of sets of tides and currents which surround them, are situated about 14 miles S.S.W. of the port of Plymouth, the sea being fully 30 fathoms in depth. A lighthouse was constructed on these rocks by Winstanley in 1696, and destroyed by a storm in 1703. A second was built by Rudyerd in 1709, and was totally consumed by fire in 1755. The present lighthouse was commenced in 1756, and completed in 1759, by Smeaton, F.R.S., civil engineer. This original model, made by Smeaton, was sent by royal command for the inspection of His Majesty George III. and the Royal Family, and has since then remained in the possession of Mr. Smeaton's family. *Mrs. Croft Brooke.*

2203a. Model of the Lighthouse on La Corbière Rock, Jersey.

Sir John Coode.

The first lighthouse constructed in concrete; tower erected in 1874. Sir John Coode, engineer. Modelled by Mr. Joseph Thomas. Scale, $\frac{1}{128}$ of natural size.

2203b. Parabolic Reflector, rendered holophotal, according to Mr. Thomas Stevenson's design, by being fitted with a lens and reflecting prisms, and a portion of a spherical mirror, so as to parallelise all the light of the lamp. Introduced in 1849.

The Commissioners of Northern Lighthouses.

When the apparatus is to be cleaned the lamp is lowered out of the reflector on a sliding carriage, as arranged by the late Mr. Robert Stevenson, in 1814. The object of the sliding carriage is to insure the return of the burner to the proper focus.

2204. Model of First-class Fixed Dioptric Light. This apparatus consists of a central lenticular band, and an upper and lower set of reflecting prisms. The cylindrical belt, with diagonal joints, and the upper and lower reflecting prisms, were substituted by Mr. Alan Stevenson, in 1836, for the segmental belt and upper and lower silvered mirrors of Fresnel's first-class apparatus.

(One-fifth of full size.)

The Commissioners of Northern Lighthouses.

2206. Model of Mr. Thomas Stevenson's Marine Dynamometer, for ascertaining the force of waves during storms. The greatest force recorded in the German Ocean was 3½ tons per square foot. *Messrs. D. and T. Stevenson.*

2207. Drawing of Storm Curve for Waves, showing the genesis of waves seawards from the windward shore, illustrative of Mr. Thomas Stevenson's formula $h=1\cdot5\sqrt{D}$, where $h=$ height of wave in feet, and D=length of fetch in miles.

Messrs. D. and T. Stevenson.

2209. Historical Series of published engravings, showing the improvements in lighthouse illumination between 1787 and 1876, by the Engineers of the Northern Lighthouse Board.

The Commissioners of Northern Lighthouses.

2209a. Ship's Light, arranged to show a port, starboard, or anchor light.—J. S. Starnes, Broad Street, Ratcliff, E.

South Kensington Museum.

2209b. Ship's Lights, port, starboard, and mast head light. —Stevens & Sons, Southwark Bridge Road.

South Kensington Museum.

XI.—MISCELLANEOUS.

Blenkinsop's Rail and two Chairs.

F. J. Bramwell, C.E., F.R.S.

This rail was designed and patented by Blenkinsop in 1811 to meet a difficulty propounded by Trevethick previously; as to the adhesion of the wheels of a locomotive engine to the rails.

Trevethick proposed that the periphery of the driving wheels of a locomotive should be made rough by the projection of bolts or cross-grooves, so that the adhesion of the wheels to the rail should be certain.

Blenkinsop, to meet Trevethick's notion, caused his rail to be made with studs or racks along one side of it, into which a toothed-wheel on his locomotive was to work. This toothed-wheel was fixed to the driving wheels of the engine, and merely served to gear into the rack on the side of the rail.

Blenkinsop's engines were carried out by Matthew Murray, of Leeds (died 1826). They had two cylinders instead of one, as in Trevethick's engine, and began to run from the Middleton collieries to Leeds, about three miles and a half, in August 1812.

The length of the piece of the Blenkinsop rail is 3 feet 5 inches. The face width 1¾ inches. Extreme depth 4½ inches. From centre to centre of the hollow half-hoop studs on the side of the rail is 6 inches.

The rail is made on the form known as fish-bellied.

Diagrams for Lecture Rooms. Steam and other machinery.
F. J. Bramwell, C.E., F.R.S.

Amongst these diagrams for lecture purposes painted in colours on black glazed linen, the following representations of interesting subjects are to be found.

Drawing of Jonathan Hull's steamboat, 1737.

Stephenson's Darlington "No. 1" locomotive engine, 1825.

Stephenson's locomotive engine "Rocket," 1829.

Cornish pumping engine with single cylinder.

Cornish pumping engine with high and low pressure cylinders. Woolf's system, 1804.

Horizontal double cylinder high and low pressure "compound" engine.

Agricultural portable engine.

Modern traction engine.

Thompson's road locomotive engine, 1870–1871.

Hancock's steam carriage, 1826.

Modern London Brigade steam fire engine.

Oscillating cylinder marine paddle engines, 1827–1876.

Modern locomotive engine on six wheels, four wheels coupled, "Cias."

Longitudinal through section of the same locomotive, "Cias," showing fire box, boiler, and boiler tubes, cylinders, connecting rods, eccentrics, &c.

2210b. Model of Tumbler Lock and Key.
The Council of King's College, London.

2210c. Model of Ancient Egyptian Lock and Key.
The Council of King's College, London.

2210d. Model of Mangle Motion.
The Council of King's College, London.

2212a. Two views of Ramsbottom's Pick-up Troughs Whitmore.
F. W. Webb, Locomotive Department, London and North-western Railway, Crewe.

These troughs are laid down to supply the tenders of the locomotives with water whilst running; a dip pipe on the tender is lowered into the water, which thus runs into the tank, by this means saving time during the journey.

2212c. Train used at the **Break Trials,** near Newark, June 9th to 15th, 1875 (2 photos.). *F. W. Webb.*

The train represented was one of the ordinary express passenger trains, fitted with continuous break, sent by the London and North-western Railway Company, to take part in the break trials at Newark in June 1875, before the Royal Commissioners.

2212d. Section of Tabular Results showing the Wear of Steel Rails. *F. W. Webb.*

2212e. Lovell's Patent Apparatus for recording the bad joints on railways and tramways. *Thomas Lowell, M.Inst.C.E*

This invention is for the purpose of showing the faulty joints in the permanent way, thus providing a means, hitherto unprovided for, for showing in the case of broken springs, or the oscillation of a train, on which side the fault rests, whether in weak springs or bad joints, and consists of a clockwork movement, arranged to draw an endless paper over suitable drums, in combination with a pencil. The indicator is attached between the spring and footplate of an engine or other vehicle, the pencil making a longitudinal line when no oscillation, and a vertical line when oscillation, takes place. The length of such vertical line is various, according to the amount of such oscillation.

The instrument exhibited is capable of taking a diagram over 120 miles of line, when attached to an engine travelling 60 miles per hour, without change of rollers, the rate of travel of the paper being 4 inches per minute; this can be reduced or regulated by adjustable flies for a lesser speed of engine.

2212k. Fog Signal. *Edward Alfred Cowper.*

This simple little instrument illustrates the application of the science of acoustics to a very useful object, namely the communication of information from a person on a railway to the driver of a passing train, in a dense fog or on a dark night; it is the only instrument that accomplishes the object, and has been the means of saving many thousands of lives. Invented by the exhibitor in 1841.

The principle consists in producing a very different sound from any that is constantly recurring in a railway train, and a sudden explosion or detonation is found to be the best for the purpose; it is caused by the explosion of a small quantity of gunpowder in a small tin box, by the firing of a match inside which is crushed by the wheel of the passing train.

Telegraph Steam Signal. *W. H. Bailey.*

2214. Model of London and its Environs. Scale 12 inches to a mile. *John Fowler, Westminster.*

Made for the purpose of showing before Committees of the Houses of Parliament the railways existing or in course of construction during the year 1864; also the proposed system of the inner circle railway, comprising the Metropolitan Railway, the Metropolitan and St. John's Wood Railway, and the Metropolitan District Railway.

2215. Improved Method of Reversing Rolling-Mills. *Jeremiah Head, M.Inst.C.E.*

A separate piece is introduced between the clutch and each clutch wheel, and connected with the latter only by elastic arms. The shock which ordinarily takes place when the clutch is thrown into gear is thus prevented.

2215a. Photograph of a Coal-testing Station.

2215b. Description of experiments on Coal relating to steam producing power; determination of the proper breadth for the spaces between the fire-bars, and treatment of the coal; ashes; weight per hectolitre; specific gravity and texture of the coal.

Berggewerkschaftskasse Bochum (Bergrath Heintzmann).

The coal experiment station is a central establishment for experiment on Westphalian coal, designed for giving exact scientific instruction as to the best uses of particular kinds of coal, and for ascertaining their comparative practical values.

2215c. Frisbie's Patent Feeder and Grate for feeding fuel up from underneath the fire into all descriptions of furnaces, fuel boxes, and fire grates, for saving fuel, securing an intense heat, and consuming the gas and smoke. *J. M. Holmes.*

This invention is designed for feeding fuel up from beneath the fire into furnaces and fire grates. No fuel is thrown upon the top of the fire, but into a charger which rocks forward to the front of the furnace under the grate bars. By turning a crank geared to a central shaft the charger is carried back under a central opening in the grate, when a piston rises in the charger and pushes the fuel up underneath the burning mass above. When the piston rises level with the top surface of the charger, it is retained in place by a catch until a reverse motion of the crank brings the charger again to the front, when the catch releases the piston and the charger is again ready for filling, the previous charge of fuel being sustained by a movable apron. The grate is constructed to revolve, so that any melted coal or slag can be brought to the door and removed quickly.

By this method of firing the ignition of the fresh coal is downwards, and all the volatilised coal, combustible gas, and carbonaceous matter pass from below through the live coals above, and break at once into flame, securing the greatest intensity of heat, and consuming the gas and smoke, thus effecting a great saving of fuel.

2216. Model of a Blast Furnace Boiler, upon elastic supports. *Jeremiah Head, M.Inst.C.E.*

Long plain cylinder boilers, when hung as ordinarily upon rigid supports, are found to rise clear of the latter at their ends when in use, and in the middle when out of use. This leads to seam rips, and frequently explosion. By turning the small hand wheel right or left, it will be seen that, by the method exhibited, the boiler is able to modify its form without straining, and consequently without danger.

2216b. Model of an Apparatus for Exchanging Despatches on Railways, without Stoppage of the Trains.

M. Cacheleux, Paris.

Delineation of the original Steam Omnibus used for a short period on the city and other roads for passenger traffic.

Gardner Collection.

2216c. Model of the late John Grantham's Patent Steam Tramway Car.

Also a detailed drawing of the above.

Mrs. John Grantham, Croydon.

2010a. Hand Bill, dated 1st June 1804, announcing the completion of the first section of the Surrey Iron Railway.
Trovey Blackmore.

This railway, which is believed to have been the first railway established in England for public traffic, was made pursuant of an Act of Parliament passed in the year 1801, by which the company was empowered to raise a capital of 30,000*l*. in shares of 100*l*. The railway was first opened from Wandsworth to Croydon, and was subsequently extended to Merstham. It passed through the valley of the Wandle, a district abounding in mills of various kinds, and conveyed the manufactures and produce of the district to the Thames at Wandsworth, where a terminus was built with large storehouses and a wet dock for the convenience of lading and unlading goods carried by water. This terminus is still in existence, though now appropriated to other uses. Large quantities of coals were conveyed inland by this railway. The rails were laid upon stone blocks or sleepers, and the cars were drawn by horses and mules. The railway was in operation till about the year 1851, soon after which time the company was wound up and the plant and property sold.

2216d. Model Railway and Carriage, invented and made by Richard Roberts, C.E., Manchester, in 1824, to illustrate the nature of centrifugal force, in his lectures at the Manchester Mechanics' Institution. A practical model.
The Committee, Royal Museum, Peel Park, Salford.

2216d. Drawing of Steam Carriage, by the late Baron Séguier, with "sun and planet wheel motion," 1846.
Late Baron Séguier, Membre de l'Institut.

2216e. Incline Carriage-way, designed for conveying passengers up and down steep hills, inclines, or sea-side cliffs, and worked by balance, hydraulic, or other machinery. *R. Hunt.*

The incline carriage-way, designed for the purpose of conveying passengers or material up and down steep inclines by means of carriages adapted to the angle of inclination and worked by means of hydraulic or other machinery, is particularly applicable to sea-side cliffs, where the sea provides an easily available motive power.

2216f. Underground Hauling Machine.
Murray and Co.

2216g. Model of London and North-Western Railway Company's Travelling Post Office and Apparatus, for picking up and setting down mail bags without stopping.
H.M. Postmaster-General.

Model of Steam Hoist used for raising the bags, &c. in the General Post Office. *H.M. Postmaster-General.*

Letter Stamping Table and Machine.
H.M. Postmaster-General.

2216f. Twelve Designs of Engineering Works executed by students, Royal College of Science, Ireland. *Prof. Pigot.*

2216e. Asbestos Packed Cocks and Valves.
John Dewrance & Co.

This entirely new principle of making cocks and valves with a bearing of asbestos, which is indestructible by heat and most of the acids, instead of the usual metal surfaces, which have to be ground together to make them tight, has stood the test of one twelvemonth's trials with perfect success.

Model of $1\frac{1}{2}$ in. cast-iron cock all nickel plated.
Drawing, framed, of 3-in. cock.
Model of 3-in. cock, cast iron, flanged.
Do. 2-in. do. do.
Do. $1\frac{1}{4}$-in. do. do.
Do. gun-metal shell and two cups.
Do. gun-metal 1-in. cock.
Do. $\frac{3}{4}$-in. water gauge.
Do. $\frac{3}{4}$-in. do. three-way.
Do. nickel plated cast-iron plug.

2216h. Captain MacEvoy's Boat Torpedo, copper, full size. *London Ordnance Company.*

A percussion torpedo to be used by a steam launch or other boat. The torpedo is fixed at the end of a long pole which is driven before the boat on torpedo service. When the torpedo comes into contact with the object of attack, it is fired by the concussion through a percussion fuze arrangement.

This torpedo is also fitted with a separate and distinct apparatus for firing at will from the boat by means of electricity ; charge of powder, 50 lbs.

Captain MacEvoy's Floating Torpedo, copper, full size, for harbour defence. *London Ordnance Company.*

To be fired by electric wire communication with the shore, or by contact. The torpedo when charged carries 60 lbs. of powder.

Captain MacEvoy's Current or Tidal Torpedo, copper, full size. *London Ordnance Company.*

The torpedo floats into a harbour amongst the shipping with the tide, and when arrested by any object, the vane is set in motion by the current's flow. In a few seconds the vane releases a hammer which falls by a spring with much force upon a percussion cap. The cap fires a detonating charge which ignites the powder or dynamite or other explosive with which the torpedo is charged. The charge of powder is 50 lbs.

Set of Torpedos for Naval use.
London Ordnance Company.

"Harvey" torpedo complete with sustaining buoys, towing lines, trigger apparatus for firing, and contact levers.

The torpedo when charged carries 100 lbs. of powder. In towing, it diverges several points to port or starboard, and when in contact with the vessel attacked, explodes itself mechanically, or electrically.

Sustaining Buoys of Cork with lines or gear complete for the "Whitehead" Torpedo.
London Ordnance Company.

Original Drawing of the Semaphore at the Admiralty, Whitehall, with code of signals and their method of arrangement. *Gardner Collection.*

Exterior View of the Admiralty with Semaphore in action. *Gardner Collection.*

XII.—BRIDGE CONSTRUCTION.

2008. Diagrams for Bridge Construction:—

a. Resistances of materials, tension, and compression.
b. Girder on two supports.
c. Graphic treatment of arches for bridges.
d. Construction of iron bridges.
Prof. Heinzerling, Aix-la-Chapelle.

2009. Photographs for the study of Construction:—

a. Bauwaage (curves of construction), a symmetrical parabola.
b. Bauwaage (curves of construction), circle.
c. Bauwaage (curves of construction), segment of a circle.
d. Bauwaage (curves of construction), ellipse.
e. Bauwaage (curves of construction), aclinoid.
f. Bauwaage (curves of construction), cubic parabola—
as lines of equilibrium. *Prof. Heinzerling, Aix-la-Chapelle.*

2092. Model of the roof of the new Polytechnic School at Dresden. *Bock and Handrick, Dresden.*

2093. Three Models of railway bridges at Niederwarthe, Corvey, and Zserks. *Bock and Handrick, Dresden.*

2093a. Cartoons (3), showing the **Terminus,** in London, of the **Midland Railway,** called St. Pancras Station.
W. H. Barlow, F.R.S.

1. General plan of station.
2. General section of station roof and flooring, with an enlarged section of one rib, showing mode of connexion with purlins. Elevation of part of one rib, showing the method of carrying the sash bars and ventilators.
3. The timber staging used by the contractors in erecting the roof.

The clear span of station roof is 240 feet; the distance between side walls, 245 ft. 6 inches; area of ground covered by the roof, 169,400 square feet; number of columns in basement supporting the flooring, 720.

The contractors for the iron work of the station and its erection were the Butterly Iron Company, Staffordshire.

The station was opened in the beginning of 1869.

2093d. Detail Drawing of Iron Lattice Girder Railway Bridges on the Pacasmayo, Guadalupe, and Magdalena Railway, 1872. Scales, 1 inch to 1 foot, and 3 inches to 1 foot.
William Willis.

The drawing represents reproductions of the original by Willis' aniline process, executed by Vincent Brooks and Co.

2098. Model of Bowstring Bridge, thrown over the canal at Wormwood Scrubs, the tunnel of the Great Western Railway passing under the canal. *Council of King's College, London.*

2216a. Model of a portion of the **Pontcysyllte Aqueduct,** which carries the Shropshire Union (late the Ellesmere) Canal across the river Dee, and the Vale of Llangollen. *G. R. Jebb.*

This model was made under the superintendence and direction of Telford before the aqueduct was built. The aqueduct consists of 19 arches, each having a span of 45 feet; the total length is 1,007 feet, and the height from the river Dee to the surface of the water in the canal is 127 feet. The foundation stone was laid on the 25th July 1795, and the work was finished in the year 1803.

This model having fallen into partial decay was a short time ago restored and repainted.

XIII. — COLLECTION OF MODELS AND DIAGRAMS ILLUSTRATIVE OF THE PRINCIPLES OF MECHANICS, ROYAL SCHOOL OF MINES.

2217. Mr. Shelley's Educational Diagrams on the Steam Engine.

2218. Educational Diagrams for illustration of **Applied Mechanics.**

Reciprocating motion in bullet-making machine.
Cams for bullet-making machine.
Machine for shaping plugs for bullets.
Reversing motion in rifling machine (2).
A parallel motion applied for rolling under pressure.
Pulleys connected by belts.
Angle of repose for various substances.
Screw press.
Dutch crane.
Differential motion.

Train of wheelwork in a crane.
A crane.
The Whitworth measuring machine.
A lathe.
Headstock of lathe.
Train for screw-cutting lathe.
Drilling machine.
Planing machine (2).
Slide rest for face lathe.
Blanchard's lathe.
Other shaping machines (3).
Arrangements for advancing boring bar.
The Cordelier.
Clock train.
Chronometer.
Regulator of watch.
Going fuzee of watch.
Rack lever escapement.
Detached lever escapement.
Chronometer escapement.
Gravity escapement.
Compensation pendulum.
Siemens' steam jet and the pneumatic despatch tube.
Principle of Giffard's injector.
Mode of supplying water to trains while running.
Air-pump of the Allen steam engine.
Husband's atmospheric stamp.
Steam hammers.
Hydraulic ram.
Cast-iron girder beams (2).
Beam of steam engine, right and wrong construction.
Girder bridges (5).
Locomotive (2).
Cylindrical boiler (2).
Marine boiler.
Forms of rail and wheel tire for locomotive (2).
Indicator diagram and slide valve of locomotive.
Hornblower's double cylinder engine.
Double cylinder engine, with piston valves.
Watt's disc valve and connections.
Fairbairn's equilibrium valve.
High-pressure cylinder, piston, and valves.
Mode of receiving thrust of screw propeller.
Gauge, with corrugated plate, and india-rubber diaphragm.
Pendulum governor (2).
Pendulum governor applied to water-wheel.
Siemens' chronometric governor.
The forge bellows.
Blowing fan, with gauge.
Guibal's ventilating fan.
Centrifugal pump.
Turbine.
Water-wheel.
Hydraulic press.
The accumulator.
Pump worked by water pressure.
Hydraulic cranes (5).
Water pressure engine (as for crane).
Press for squirting metals.

2219. Mr. Anderson's Educational Diagrams on Mechanics.

Levers (12).
Wheel and axle (18).
Pulley (8).
Inclined plane (8).
Wedge (8).
Screw (10).
Dynamometers (3).
Toggle joint.
Virtual velocities.
Hydraulic press.
Elastic cords.
Pumps (2).

2220. Model to show the Conversion of Circular into Reciprocating Motion, in one direction only.

2221. Model to show the Conversion of Circular into Reciprocating Motion, in two perpendicular directions.

2222. Model to show Inequality of Motion, when a crank and connecting rod are used; also that the linear motion may be doubled when the connecting rod is equal in length to the crank.

2223. Diagram Model, with parts to illustrate the movements when the connecting rod is equal to the crank. Straight line motion.

2224. Three Models of an Eccentric Circle.

2225. Model to show Conversion of Circular into Reciprocating Motion, with intervals of rest.

2226. The Swash Plate.

2227. Crown Wheel Escapement.

2228. Simple form of Escapement.

2229. Recoil Escapement for Clocks.

2230. Dead-beat Escapement.

2231. Various forms of Escapement.

2232. Wheel, with one tooth and locking ring.

2233. Geneva Stop.

2234. Model of Recoil Escapement, for throwing an image on a screen by the electric lamp.

2235. Model of Dead-beat Escapement, for throwing an image on a screen by the electric lamp.

2236. Striking Movement of a Clock (locking plate).

2237. Striking Movement with Repeater.

2238. Model to illustrate Compensation Balance Wheel of Chronometer.

2239. Model of Wheel and Axle.

2240. Pulley Block.

2241. Disc and Roller Motion.

2242. Two forms of Screw Thread.

2243. Two Models to show the principle of Counting Machines.

2244. Counting Machine.

2245. Model to show Reversing Motion of the Table in Whitworth's Planing Machine.

2246. Model of Double Rack and Pin Wheel.

2247. Model of Cams in combination, taken from a machine for shaping plugs for bullets.

2248. Cam to Write the letters R.I. (Cowper's Model).

2249. Worm Barrel.

2250. Reversing Motion, with two and three spur wheels (quick return).

2251. Reversing Motion with Clutch.

2252. Model of Train of Wheels.

2253. Specimen of Spur Wheel.

2254. Two Models of Slit-bar Motion.

2255. Application of Slit Bar Motion in Whitworth's shaping machine.

2256. Two Models of Ratchet Wheels.

2257. Masked Ratchet Wheel.

2258. Silent Ratchet Wheel.

2259. Model to show Advance of a Ratchet Wheel through part of the Space of a Tooth.

2260. Ratchet Wheel, for traversing the cutter in a planing machine. Clement's Click.

2261. Machine for Printing Numbers.

2262. Drawing of a Lathe. (Whitworth.)

2263. Drawing of a Planing Machine. (Whitworth.)

2264. Apparatus to show that Friction is independent of Velocity.

2265. Apparatus to illustrate Friction Grips, and for experiments on the laws of friction.

2266. Model to show when a Drawer jams.

2267. Model to explain Weston's Friction Clutch.

2268. Silent-feed Motion (Worssam).

2269. Apparatus for illustrating the Angle of Repose between Two Surfaces.

2270. Plummer Block, showing Cylindrical Bearing.

2271. Form of Conical Bearing.

2272. Model of Friction Wheels.

2273. Model of Single Pulley Block.

2274. Two Models of Unbalanced Wheels.

2275. Model of an Arch.

2276. Model of Jointed Sword (Cowper).

2277. Model of Continuous Action Pump.

2278. Model of Pendulum, arranged for beating Time.

2279. Model for Tracing the Curves in the Slit Bar Motion.

2280. Two Models of Eccentric Rosette Motion.

2281. Various Models to show the production of Measuring Bars for End measure.

2282. Model to illustrate the conversion of Linear into End measure.

2283. Model to show Principle of Roberval's Balance.

2284. Balance on Roberval's Construction.

2285. Weighing Machine.

2286. Frame for experimenting with Epicyclic Trains, and with other trains, as in a screw-cutting lathe.

2287. Model of Combined Joints.

2288. Two forms of Ball and Socket Joint.

2289. Model of Hooke's Joint.

2290. Two Models of a Double Hooke's Joint, with adjustments.

2291. Mode of Connecting Parallel Axes.

2292. Parallel Axes, connected by a fork and grooved disc.

2293. Motion between Inclined Axes.

2294. Parallel Axes with Cranks and Links.

2295. Pair of Cranks, connected by a link, with adjustments.

2296. Mode of connecting Parallel Axes.

2297. Earliest Contrivance for feathering Floats in Paddle Wheels.

2298. Model of Link Motion in a Wool Combing Machine.

2299. Model of a Ventilating Fan.

2300. Model of Knuckle Joint.

2301. Knuckle Joint, with crank and connecting rod.

2302. Model of Stanhope Levers.

2303. Model of Lever Shears.

2304. Circular into Reciprocating Motion, with four beats for each rotation.

2305. Circular into Reciprocating Motion, with alternate intervals of rest.

2306. Model of Screw Surface.

2307. Model to show Difference of Inclination in Screw Threads of the same pitch, traced on cylinders of different diameters.

2308. Model of Endless Screw and Worm Wheel.

2309. Rolling Contact between Hyperboloids, with generating line mounted separately.

2310. Model of Skew Bevels.

2311. Two Axes, connected by a cord and grooved pulleys.

2312. Chain and Pulley.

2313. Pantograph, for drawing similar curves.

2314. Model of Watt's Parallel Motion.

2315. Model to illustrate the principle of Watt's Parallel Motion.

2316. Outline Model of Beam Engine, with Watt's parallel motion.

2317. Model of Roberts' Parallel Motion.

2318. Model of Peaucellier's Straight-line Motion.

2319. Sectional Model of a Trunk Engine.

2320. Model showing Expansion Valve.

2321. Model of Watt's Pendulum Governor.

2322. Model of the Cataract as applied to single-acting engines.

2323. Model of Silver's Marine Governor

2324. Cornish Crown Valve.

2325. Hawthorn's Safety Valve.

2326. Richard's Indicator.

2327. Diagram Model for setting the Slide Valve of a Horizontal Engine.

2328. Mode of reversing Marine Engine by a single eccentric.

2329. Model of Stephenson's Link Motion.

2330. Model of Steam Pump with Valve inside the Piston.

2331. Sectional diagram Model of the Pump.

2332. Giffard's Injector.

2333. Model of Slide Valve and Ports.

2334. Right and left handed Screw.

2335. Models to illustrate Ferguson's Paradox.

2336. Model to illustrate Silver's Marine Governor.

2337. Three Bevel Wheels forming Epicyclic Train.

2338. Model to explain the Differential Dynamometer.

2339. Differential Motion.

2340. A Geometrical Pen, showing application of an epicyclic train to the drawing of curves.

2341. Model to illustrate the principle of the Geometrical Pen.

2342. Model to illustrate Rope-making.

2343. The Cordelièr.

2344. Model of expanding and contracting Crank.

2345. Model of Differential Pulley (Saxton's Patent).

2346. Lazy Tongs.

2347. Model for generating a Cycloid.

2348. Model of Headstock of a Lathe.

2349. Model of Collier's Planing Machine.

2350. Model of a Drilling Machine.

2351. Two Models illustrating Whitworth's Drilling Machine.

2352. Model of Eccentric Chuck.

2353. Model to illustrate Houldsworth's Differential Motion.

2354. Model of Screw Propeller.

2355. Model of a pair of Locomotive Wheels.

2356. Model of Hindley's Screw.

2357. Rolling contact between Ellipses.

2358. Elliptical Wheels, for obtaining a quick return in shaping machine.

2359. Variable motion from Wheels set eccentrically.

2360. Model of Roemer's Wheels.

2361. Method of altering or stopping the reciprocation of an Arm without stopping the prime mover.

2362. Model for comparing Bourdon's Gauge with Mercurial Pressure Gauge.

2363. Model to show principle of Bourdon's Gauge.

2364. Model of Wave Line Cam.

2365. Model of Heart Cam.

2366. Cam with Pulleys and Band.

2367. Model to illustrate Slit Bar Motion.

2368. Model of Spur Wheels.

2369. Model of Perrault's Wheel and Axle.

2370. Model of Blowing Fan.

2371. Model of Centrifugal Pump.

2372. Model of Screw.

2373. Model of Pump with revolving Belt.

2374. Model to explain the Hydrostatic Press.

2375. Whirling Table for Suspended Objects.

2376. Models of Pyramid, Cone, Cylinder, Ring, Chain, and weighted piece, for experiments on rotation.

2377. Whirling Table.

2378. Model to show effect of Rotation on a cork and a bullet in tubes of water.

2379. Flask arranged for experiments on Rotation.

2380. Model to explain Siemens' Water Governor.

2381. Model to explain Ramsbottom's Velocimeter.

2382. Various Models showing effects due to Rotation.

2383. Apparatus for showing the effect of the atmosphere in causing a spherical bullet to deviate laterally.

2384. Balls swinging in a Cycloid.

2385. Models of Cone and Paraboloid.

2386. Two forms of Gyroscope.

2387. Model of Pendulum, with adjustments.

2388. Model of Accumulator, with Press.

2389. Sectional Model of Locomotive.

2390. Belt on Pulleys at right angles.

2391. Action of Convex Pulley on a Belt.

2392. Models to show the principle of Lattice Girder Beams.

2393. Whitworth's Bench Measuring Machine, to measure intervals differing by one ten thousandth of an inch, and for constructing difference gauges.

2394. Apparatus for obtaining a Rectangular Measuring Bar with plane ends at right angles to its axis.

2395. Hexagonal Surface Plates.

SECTION 13.—CHEMISTRY.

WEST GALLERY, UPPER FLOOR, ROOM (P).

I. HISTORICAL.

2401. Balance used in his experiments by Dr. Joseph Black, Professor of Chemistry in the University of Edinburgh, from 1766 to 1799. Dr. Black was the discoverer of fixed air (carbonic acid), and author of the theory of latent heat.

Edinburgh Museum of Science and Art.

2398. Balance used by **Cavendish.**

The Royal Institution of Great Britain.

This balance, of rude exterior but singular perfection, was made by Harrison according to the plan and by order of Henry Cavendish, Esq., and passed at his death to his cousin and heir, Lord George Cavendish. By him it was presented to Sir Humphry Davy, together with the greater part of Mr. Cavendish's philosophical apparatus. Presented to the Royal Institution of Great Britain by Mr. Felix R. Garden.

2401a. Balance used by, or formerly belonging to, Dr. Priestley. *William Sykes Ward.*

This is remarkable as a good specimen of early work, having friction pulleys for suspending the beam; also an interchangeable piece with steel planes, gearing for raising the beam concealed in foot, extra pans and glass bucket for taking specific gravities. The successive owners of the balance are believed to have been: Dr. Priestley (Leeds), Abraham Sharpe (Bradford), Joshua Muff (Leeds), and the Exhibitor.

2400. Balance used by **Sir Humphry Davy**. Presented to Professor Roscoe by Mrs. F. Crace-Calvert.

Prof. Roscoe, F.R.S.

2399. Balance used by **Dr. Thomas Young** and **Sir Humphry Davy.** *The Royal Institution of Great Britain.*

A balance made by Fidler for the Royal Institution, nearly resembling those of Ramsden and Troughton. "Lectures on Natural Philosophy," by Thomas Young, M.D., 1807. "Works of Sir Humphry Davy," vol. 5, page 17.

2537. Pneumatic Trough used in his experiments by Dr. Joseph Black, Professor of Chemistry in the University of Edinburgh, from 1766 to 1799. Dr. Black was the discoverer of fixed air (carbonic acid), and the author of the theory of latent heat.

Edinburgh Museum of Science and Art.

2538. Glass Chemical Vessels (retort, bottle, and flask or receiver) used in the chemical laboratory of the University of Edinburgh during the latter half of last century. Exhibited to show the contrast between them and vessels used for similar purposes at the present day.

Edinburgh Museum of Science and Art.

2396. Apparatus employed by **John Dalton** in his **Researches.**

The Council of the Literary and Philosophical Society of Manchester.

The apparatus employed by John Dalton in his classical researches, whether physical or chemical, was of the simplest and even of the rudest character. Most of it was made with his own hands, and that which is exhibited has been chosen as illustrating this fact, and as indicating the genius which with so insignificant and incomplete an experimental equipment was able to produce such great results. The Society has in its possession a large quantity of apparatus used by Dalton, most of which however consists of electrical apparatus, models of mechanical powers, models of steam engines, air pumps, a Gregorian telescope, and other apparatus of a similar kind, which was either bought or presented to him. It has not been thought necessary to exhibit these, but rather to show the home-made apparatus with which Dalton obtained his most remarkable results.

I. *Meteorological and Physical Apparatus made and used by Dr. Dalton.*

Throughout his life Dalton devoted much time and attention to the study of meteorology; indeed his first work, published in 1793, was entitled "Meteorological Observations and Essays," and his last paper, printed in 1842,* (Mem. Lit. and Phil. Soc. VI. 617) consists of auroral observations. Hence the first of Dalton's apparatus which claim attention are the meteorological instruments.

No. 1 is Dalton's mountain barometer, with accompanying thermometer, made for him by the late Mr. Lawrence Buchan of Manchester. The barometer is enclosed in a wooden case, which Dalton was accustomed to carry in his hand.

Several home-made barometers used by Dalton in his observations are in possession of the Society. They are all of them filled, and the scales prepared, by Dalton himself, and are simple siphon tubes with a bulb blown on at the bottom to serve as a mercury reservoir. These are attached to plain pieces of deal, upon the upper part of which the paper scale is pasted. One of these, which has probably also served for tension experiments (No. 2), has been placed in the collection.

Many of the thermometers appear also to have been home-made.

No. 3 is a mercurial thermometer, evidently made and graduated by Dr. Dalton, and marked with his initials, J. D. The freezing point of this thermometer was tested recently by Mr. Baxendell, who found that it had not altered since the instrument was graduated.

Another (No. 4) is of the same kind, and bears the date 1823.

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* *Vide* Life of Dalton by Dr. Henry, published by the Cavendish Society; Memoir of Dr. Dalton and the History of the Atomic Theory, published in the Memoirs of the Literary and Philosophical Society of Manchester, 2nd Series, Vol. I.; Dr. Lonsdale's Life of Dalton, Longmans, 1874.

No. 5 is a third mercurial thermometer with long stem and wooden scale.

No. 6 is an alcohol thermometer with wooden scale.

No. 7 a registering maximum and minimum thermometer employed by Dalton; maker's name J. Renchetti, 29, Balloon Street, Manchester.

II. *Apparatus constructed and used by Dalton in his Researches.*

(1) "On the constitution of mixed gases," (2) "On the force of steam or "vapour from water or other liquids at different temperatures both in a Torri- "cellian vacuum and in air," (3) on evaporation, and (4) "On the expansion "of gases by heat."*

No. 8 is an apparatus used for the determination of the tension of volatile liquids at low temperatures; it consists of a siphon tube, at the upper end of which is a scale in inches in Dalton's handwriting. He describes it thus:

"I took a barometer tube 45 inches in length, and having sealed it hermetically at one end, bent it into a siphon shape, making the legs parallel, the end that was closed being 9 inches long, the other 36 inches. I then conveyed two or three drops of ether to the end of the closed leg, and filled the rest of the tube with mercury, except about 10 inches at the open end. This done, I immersed the whole of the short leg containing the ether into a tall glass containing hot water."

No. 9 is a smaller tube containing another liquid, also having a graduated scale written on paper and attached to the tube.

Nos. 10, 11, 12, 13, 14, are tubes used by Dalton for measuring the tension of vapour from water and other liquids at higher temperatures than their boiling points, both in a vacuum and air.

No. 15 is a tube used by Dalton for measuring the tension of the vapour of bisulphide of carbon, labelled "Sulphuret carb.," with a paper scale in Dalton's handwriting, and a cork showing that the upper portion of the tube containing the bisulphide of carbon could be heated in a water bath to various temperatures.

No. 16 is a manometer tube, fixed into a board, divided and numbered by Dalton.

No. 17 is an apparatus used by Dalton for the determination of the tension of the vapour of ether, and is interesting as being the instrument by means of which Dalton arrived at one of his most important experimental laws. It is described as follows (p. 564):—

"The ether I used boiled in the open air at 102°. I filled a barometer tube with mercury moistened by agitation in ether; after a few minutes a portion of the ether rose to the top of the mercurial column, and the height of the column became stationary. When the whole had acquired the temperature of the room (62°) the mercury stood at 17·00 inches, the barometer being at the same time 29·75 inches. Hence the force of the vapour from ether at 62° is equal to 12·74 of aqueous vapour at 172° temperature, which are 40° from the respective boiling points of the liquids."

This is generally known as Dalton's law of tensions, since shown by Regnault not to be rigorously true.

No. 18 is a wet and dry bulb mercurial thermometer made by H. H. Watson, of Bolton.

III. *Apparatus for Measuring Gases and for determining the Solubility of Gases in Water.*

No. 19 is an apparatus with a graduated tube, probably used by Dalton for the determination of the laws regulating "the absorption of gases by water

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* Experimental essays on the above subjects, by John Dalton, read October 2nd, 16th, and 30th, 1801, and published in the 1st series, vol. 5, part 2, of the Memoirs of the Literary and Philosophical Society of Manchester.

"and other liquids," read October 21st, 1803. "Manchester Memoirs." 2nd Series. Vol. 1.

No. 20 is a graduated glass tube attached to a bottle of india-rubber, also probably used in his researches on the absorption of gases by water.

No. 21, No. 22, are divided eudiometer tubes, employed by Dalton for measuring the volumes of gases.

No. 23 is a spark eudiometer.

Nos. 24, 25, 26 are glass tubes, pipettes, and funnels graduated by Dr. Dalton and used by him for measuring gases.

No. 27 is a graduated glass bell-jar, used for measuring gases.

No. 28 is a phial, with graduated tube attached by cement, for collecting and measuring gases.

Nos. 29, 30 are stoppered phials, with the bottoms cut off, used as gas jars for collecting and measuring gases.

No. 31 is a thousand grains specific gravity bottle, with its counterpoise of lead stamped "175" by Dalton, and paper labelled in his handwriting "bottle balance."

No. 32 is a pipette.

No. 33, square bottle of thin glass, fitted with brass caps, and probably used for the determination of the specific gravities of gases.

No. 34 is an earthenware cup, used by Dalton as a mercury-trough, and containing a small phial with mercury.

Nos. 35, 36 are bulb tubes, with graduated scales, serving for the determination of the coefficients of expansion of gases.

No. 37 is a Florence flask with cork and valve for determining the specific gravity of gases.

No. 38 is a glass alembic.

IV. *Weights, Balances, Apparatus, Reagents, and Specimens used by Dalton.*

No. 39, eleven phials, containing creosote, iodine, amalgam of bismuth and mercury, quercitron bark, grana sylvestra, cochineal, and other substances, labelled in Dalton's handwriting.

No. 40, three divided blocks, used by Dalton for the illustration of his lectures; these are not, however, the balls an inch in diameter (referred to in his latest memoir on the "Analysis of Sugar") which he employed occasionally in his lectures, as illustrating his newly-discovered laws of combination and the atomic theory; these appear, unfortunately, to be no longer in existence.

No. 41 is a common pair of scales used by Dalton.

No. 42, a pair of apothecary's scales and weights employed by Dalton, with a paper of weights made of wire, labelled in his handwriting, "100th grains."

No. 43 is a box of weights used by Dalton, and containing a pill box labelled "Platina," another pill box labelled "Hund," and containing 100th of grains, and another wooden box containing brass gramme weights, labelled "Weights, French;" the other ordinary weights are of lead.

No. 44 is Dalton's pocket balance, consisting of a small pair of apothecaries' scales, with beam about 4 inches long, and having the pans attached by common string; it is contained in a tin case for the pocket.

No. 45 is a penholder used by Dalton.

No. 46, leaden grain weights made by Dalton from sheet lead, and stamped in numbers by him.

No. 47, iron punches used by Dalton for this purpose.

No. 48, a glass lens, wrapped in a piece of paper, labelled in Dalton's writing, "Sun's focus 4·2 inches."

No. 49 is a paper containing "10th of grains," made by Dr. Dalton of iron wire. The paper in which these are wrapped is part of a note from one of

Dr. Dalton's pupils (as is well known, he lived by teaching mathematics at half-a-crown per lesson), in which the writer presents his "complements to "Mr. Dalton, and is sorry that he will not be able to wait upon him to-day, "as he is going to Liverpool with a few friends who are trying the railway "for the first time. Mr. D. may fully expect him on Monday at the usual "time."

No. 50 are bottles of tin, earthenware, and silver, some of them being common penny pot ink bottles. Each has a thermometer tube cemented into the neck of the bottle, and these tubes are provided with paper scales. These were used by Dalton probably for experiments on radiant heat.

No. 51 is a manometer tube used by Dalton; it consists of a tin vessel attached on either side to leaden tubing, and having a thermometer-tube closed at the upper end, and provided with a divided scale, fixed into the upper portion of the tin vessel.

No. 52, Dalton's Balance, made by Accum, and capable of arrangement as hydrostatic-balance with weights and counterpoises.

2397. Frame containing proofs in **John Dalton's** handwriting of part of the "New System of Chemistry." Vol. II., Part I., pages 347, 349, and 352. *Prof. Roscoe, F.R.S.*

2397a. Receipt by John Dalton for instruction in Chemistry. *C. Law.*

2418. Press used by Dr. W. H. Wollaston, to compress Platina, obtained in a fine state of division from precipitated chloride. *G. H. Wollaston.*

By means of this press the force obtained when the handle is at an angle of 5° is very nearly 60 × by power, and at an angle of 1° very nearly 300 × by power.

2418a. Rhodium extracted from Platinum Ore by Dr. W. H. Wollaston. Probably also contains Iridium and Ruthenium.
G. H. Wollaston.

2418b. Platinum Crucible and Platinum Trough, used by Dr. W. H. Wollaston. *G. H. Wollaston.*

1738. Portion of the **Battery used by Sir Humphry Davy** in decomposing the alkalies.
The Royal Institution of Great Britain.

Phil. Trans. 1808.

687b. Sir Humphry Davy's Laboratory Note Book.
The Royal Institution of Great Britain.

Davy's record of his decomposition of potash by the voltaic battery, October 19, 1807.

2405. Faraday's Apparatus for the **Condensation** and **Liquefaction** of **Gases.**
The Royal Institution of Great Britain.

Apparatus used by Faraday for the condensation and liquefaction of gases, consisting of condensing pump and connexions, conducting and other tubes, gauges, sealed tubes for containing the liquefied gases, &c. &c.—Phil. Trans. 1845.

2406. Original Tubes containing Gases liquefied by Faraday. *The Royal Institution of Great Britain.*

1.
2.
3. Muriatic Acid.
4.
5.
6. Carbonic Acid.
7. Nitrous Oxide.
8. Sulphurous Acid.
9.
10. Cyanogen.
11. Ammonia.
(Phil. Trans. 1845.)
12. Arseniuretted Hydrogen.
13. Ammonia.
14.
15. Hydrobromic Acid.
16. Chlorine.
17.
18. Chlorine and Sulph. Acid.
19. Sulphuretted Hydrogen.
20. Hydriodic Acid.
21. Arseniuretted Hydrogen.

687c. Faraday's Laboratory Note Book.
The Royal Institution of Great Britain.

Faraday's record of his condensation and liquefaction of gases, March 19, 1823.

Apparatus used by Brande for the continuous preparation of Ether.
The Royal Institution of Great Britain.

2409a. Original Apparatus, by M. Dumas, for ascertaining the density of gases. *M. J. Dumas, Paris.*

2409b. Apparatus, by M. Dumas, for ascertaining the density of vapours. *M. J. Dumas, Paris.*

APPARATUS EMPLOYED BY THE LATE THOMAS GRAHAM, F.R.S., MASTER OF THE MINT, IN HIS PRINCIPAL RESEARCHES BETWEEN THE YEARS 1834 AND 1866. The series is interesting as showing the simplicity of the appliances with which Graham worked, and by the aid of which he discovered facts and established laws which have since proved to be of so much importance.
W. Chandler Roberts, F.R.S.

2539. Tubes with discs of graphite and hydrophane employed by Graham in experiments on "diffusion" of gases.

These experiments were commenced in 1834, when the discs were formed of plaster of Paris. The instrument consists of a graduated glass tube, open at one end and closed at the other by the porous substance. When such a diffusion tube is filled with a gas over mercury an interchange of the gas and the air takes place through the porous septum. By experiments such as these Graham determined the diffusion rates of different gases, and developed the law that their diffusibilities vary in the inverse ratio of the square roots of their densities.

2540. The Apparatus employed for ascertaining the diffusion rates of liquids (Bakerian Lecture, 1849).

The saline solution to be diffused was placed in the inner vessel, which communicated freely with distilled water in the outer vessel. It was shown by this means that, when two liquids of different density and capable of mixing are placed in contact, diffusion takes place between them, much in the same manner as between gases, except that the rate of diffusion, which varies with the nature of the liquids, the temperature, and the degree of concentration, is slower. The phenomena are governed by several well ascertained laws, for a brief account of which *see* Watts's Dictionary of Chemistry, Vol. III., p. 705.

2541. Osmometers, or apparatus employed in Graham's researches on **"Osmotic Force."**

When a solution of a salt in a liquid is separated by a membrane or porous septum from a mass of water, a flow of liquid takes place from one side of the septum to the other. In some cases this flow is sufficiently powerful to sustain a column of water several inches in height. This diffusion is termed "Osmose." The experiments of Graham led to the conclusion that osmose depends essentially on the chemical action of the liquid on the septum. The base of the bell glass is covered either with thin unglazed earthenware or animal membrane, and is of such a size that the area of the opening is 100 times that of the tube, in order to facilitate the observations.

2542. Apparatus employed in experiments on **Liquid Diffusion** applied to analysis and on dialysis.

It consists simply of a gutta-percha hoop, about 9 inches in diameter, on which is stretched a sheet of parchment paper. The solution to be dialysed is placed in the hoop, and the whole floated in a considerable volume of water. Animal membrane, or a mere film of a colloidal septum, permits crystalloids to diffuse freely through it, but is entirely impervious to any colloids, for example gelatine, which may be in solution. The septum does not act in any way as a filter, but permits only the permeation of molecules and not masses. This mode of diffusion Graham termed Dialysis. By its aid he obtained hydrated silicic acid, oxides of iron and alumina, &c., all soluble in water, and he succeeded in separating crystalloid poisons from organic matter in toxicological investigations.

2543. Apparatus by which Graham studied **Capillary Liquid Transpiration** in relation to chemical composition.

The globe was filled with the liquid under examination, and the force employed to impel it through the capillary was the weight of 1 atmosphere, and was obtained from compressed air contained in the large reservoir, which was provided with a mercurial gauge.

2544. Tube Atmolyser, or instrument for the **separation of Gases by diffusion.**

As gases differ in the rate at which they transpire through a porous septum, it follows that, when a mixture of gases is in contact with a septum, while the other side is vacuous, the per-centage composition will be changed. The atmolyser consists of a bundle of tobacco-pipe stems, enclosed in a glass tube, which can be rendered vacuous. The mixed gases are passed through the tube. For example, an explosive mixture of 66 per cent. by volume of hydrogen and 33 per cent. of oxygen was passed through the tube. The resulting mixture contained only 9·3 per cent. of hydrogen, and a taper burned in it without explosion.

2545. Barometrical Diffusiometer, used for the investigation of the **Molecular Mobility of Gases.**

The gas under examination was allowed to enter either a perfect or partial vacuum through a thin porous septum. The results proved that the diffusion rates of the gases closely correspond with the law which has already been given, and quite excluded the idea of capillary transpiration, which would give for the same gases an entirely different result.

2546. **Apparatus** employed in experiments on **Absorption** and **dialytic separation of Gases by Colloid Septa.**

(1.) Waterproof silk bag for the dialysis of air. When the bag is exhausted by means of a Sprengel pump the air which penetrates the walls of the bag is found to contain 42 per cent. of oxygen, that is, the per-centage of oxygen present is doubled.

(2.) The penetration of metals by gases was studied by the aid of metallic tubes, of which the palladium tube shown is one. It was enclosed in a tube of glass or porcelain, and rendered vacuous by the aid of a Sprengel exhauster; a stream of gas was then passed through the annular space between the tubes. In the cold no hydrogen will pass through palladium, but at a red heat the gas passes at a rate of nearly 4,000 cubic cent. per square metre of surface in a minute.

2603. E. Mitscherlich's Vapour Density Apparatus.

Prof. A. Mitscherlich, Münden.

This apparatus is described in E. Mitscherlich's text-book of chemistry, p. 308, and was employed by him in determining the specific gravity of vapours.

II. MODELS, DIAGRAMS, APPARATUS, AND CHEMICALS EMPLOYED IN OR RESULTING FROM CHEMICAL RESEARCH.

2407. **Apparatus** by which Dr. Andrews and Professor Tait proved that ozone is a condensed form of oxygen.

Dr. Andrews, F.R.S.

Dry oxygen gas is exposed to the action of the silent electrical discharge in a glass tube terminating in a U tube containing sulphuric acid, which indicates by its change of position the change of volume in the gas.

2409. **Apparatus** used for ascertaining the **Density of Ozone.**

J. Louis Soret, Geneva.

This process, based upon the velocity of diffusion, has been described in detail in the "Recherches sur le Densité de l'Ozone" (Archives des Sciences physiques et naturelles, 1867, Vol. 30, p. 328. Annales de Chimie et de physique, 1868, Vol. 13, p. 264). Constructed by the Geneva Association for the Construction of Scientific Instruments.

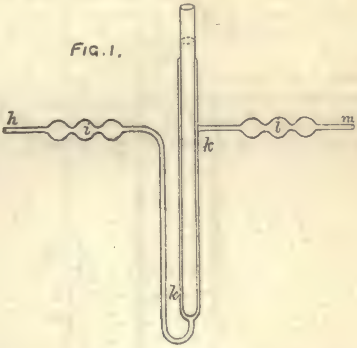
2547. Apparatus for Gas Experiment, as used for the determination of the Composition of Ozone.

Sir B. C. Brodie.

This apparatus will be described in the form in which it was employed for the determination of the composition of ozone, the object being to determine the changes which electrized oxygen underwent when subjected to the action of heat or of chemical reagents.

A current of pure and dry oxygen was passed through an induction tube, fundamentally of the kind devised by Siemens, but the inner tube was nearly filled with water, in which was placed one of the terminal wires of Ruhmkorff's coil, the tube itself being immersed in a vessel of water connected with the other terminal wire of the coil. The tube is delineated in Fig. 1. The gas enters the apparatus at *h*, and, passing over anhydrous-phosphoric acid contained in the three bulbs *i*, traverses the narrow space *k* between the two tubes, and is there submitted to the electric action, after which the electrized gas is again passed over anhydrous phosphoric acid contained in the three bulbs *l*, and is delivered at *m*.

FIG. 1.



The electrized gas is collected and preserved for the purpose of experiment in a gas-holder, delineated in Fig. 2. On this side of the induction tube connexions of caoutchouc can no longer be employed, this substance being instantaneously corroded by even the minutest trace of ozone, and the friction between the gas-holder and the induction-tube is effected by means of what may be termed a paraffin joint. Over the tubes to be connected, which are placed close together, is slipped a piece of glass tube into which they exactly fit, and from which they are separated by a capillary space; a fragment of pure paraffin is placed at the external junction of the tubes. The union of the tubes is effected by gently melting the paraffin; the liquid paraffin is extremely limpid, and runs into and fills up the narrow space between the tubes. When the paraffin is solidified, the tubes are united by a joint, which is perfectly air-tight, which will resist very considerable pressure, and which is quite unaffected by the passage of the ozone. This simple joint is an essential feature of this arrangement, and will doubtless be of great service in many forms of gas apparatus.

The gas-holder consists of a glass bell *p*, contained in a glass cylinder *q*, in which it is suspended, being supported by a knob of glass passing through a cap fitted to the top of the jar. This cap is made in two pieces, which are subsequently united so as to be readily placed in a proper position as a support to the glass bell.

At a superior level is placed a glass jar *r*, containing pure and concentrated sulphuric acid; this jar is connected by a syphon tube *s* (in which is placed a glass stop cock) with the lower cylinder *q*. This upper jar, which I shall term the reservoir, is closed by a cap *t*, through which the siphon tube passes, and in which is also fitted a second glass tube *u*. The gas from the induction tube is delivered at *n*, whence it passes into the gas-holder by an arrangement of tubes, which is best understood from the drawing. The passage of the gas is regulated by means of an air pump, connected with the glass tube *u* by a tube of caoutchouc.

The volume of gas submitted to experiment was measured in a glass pipette, of which a drawing is given in Fig. 3. The capacity of the pipette (290·8 sub-centimes) between the two marks *b* and *c* was estimated by calibration with mercury. It was then welded to a glass tube of the form given in the figure; *e* is a reservoir of sulphuric acid with a syphon tube attached; *d* a cylinder containing water, in which the pipette *a* is immersed, and in

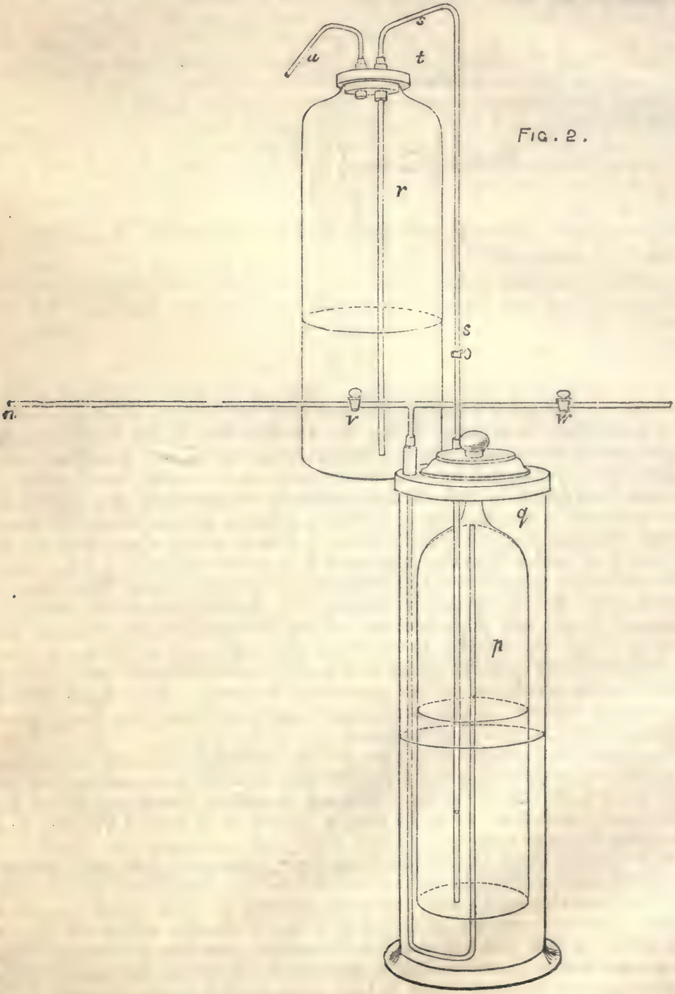


FIG. 2.

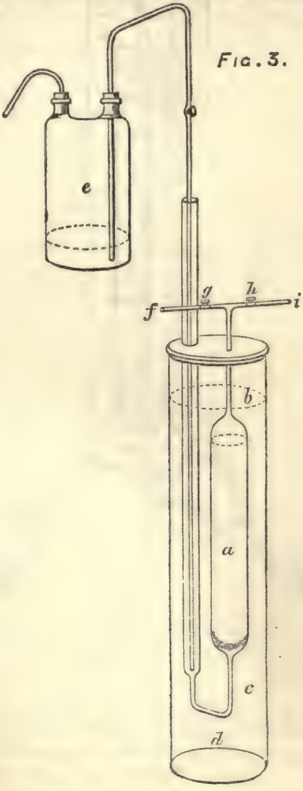
which a thermometer is placed. The gas pipette is connected with the gas holder by a paraffin joint at *f*. The arrangements for working this pipette are similar to those in the case of the gas-holder.

In order to estimate the changes in bulk which the electrized gas underwent in the various experiments hereafter described, the measuring apparatus was employed, of which a drawing is given, Fig. 4. In this apparatus, which I shall term the aspirator, the volumes of gas at 0° C. and 760 millims. pressure is ascertained by determining the pressure which it is necessary to put upon the gas in order to cause it to occupy a known space at a known temperature. This is the principle of Regnault's apparatus for gas analysis, and also of Frankland's apparatus.

The pipette was placed on a table, being separated from the aspirator by an interval of about 8 or 10 inches. In this interval the experiment to which the electrized gas was submitted was made.

The aspirator consists of a cylinder of strong glass *a*, connected by an iron tube with an iron reservoir, *b*, containing an amount of mercury rather more than sufficient to fill the cylinder *a*. In the iron tube connecting the cylinder and the reservoir is intercalated a stopcock *c*, by which the connexion

FIG. 3.



between the cylinder and reservoir may at pleasure be made or cut off. In the reservoir *b* a small iron tube *d* is inserted, connected by a tube of caoutchouc with a forcing pump firmly fixed to the table on which the apparatus is placed. By means of this forcing pump the air contained in the upper part of the reservoir may be compressed, and any required pressure put upon the mercury contained in it. The cylinder *a* is cemented by means of a resinous cement into two steel caps, *e* and *f*; the lower cap *f* is screwed firmly upon the support of the apparatus, which is made of iron. The cylinder is connected by means of a channel cut in the lower part of the steel cap *f* and continued through the iron frame, with a glass tube *g*, which is

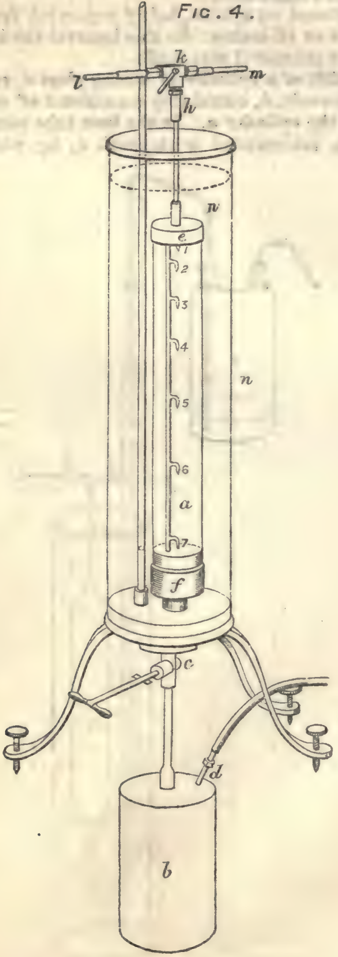


FIG. 4.

about half an inch in diameter and graduated in millimetres. This tube I shall speak of as the pressure tube. The cylinder *a* and the pressure tube *g* are thus in permanent connexion, and constitute one vessel, which is broken into parts solely for facility of construction. This apparatus is supported upon three screws, as shown in the figure, by the adjustment of which the pressure tube *g* is placed in a perpendicular position before the commencement of the experiment. The steel stopcock *k* is a three-way stopcock, in which the channels are so cut that a communication may be made between the tube *l* and the cylinder *a*, or between the tube *m* and the cylinder *a*, or between the tubes *l* and *m* (all other communications being shut off) at pleasure; or the communications may be entirely closed.

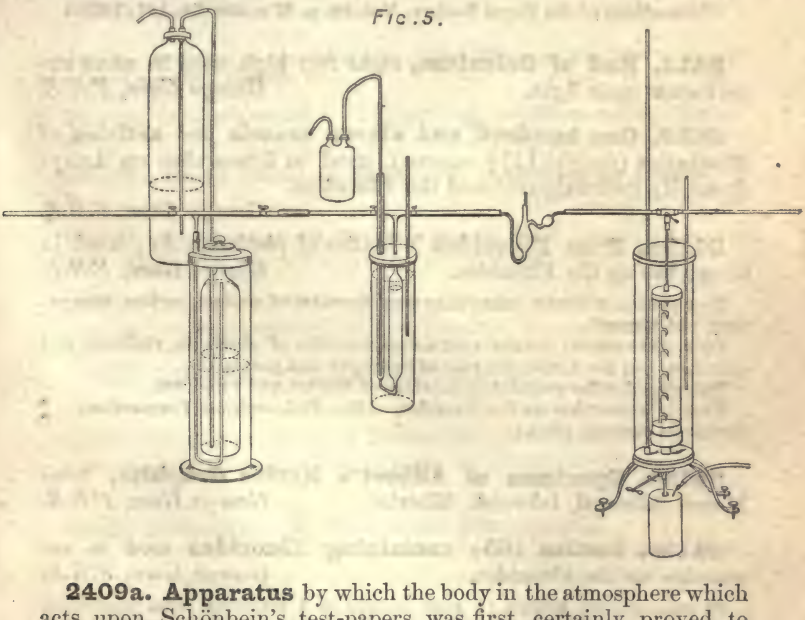
In the cylinder *a* is placed a thin piece of glass rod, to which seven points are attached, also of glass, as shown in the figure. The capacity of the cylinder *a* between each point is ascertained by calibration with mercury.

The cylinder and pressure tube are enclosed in a second glass cylinder *n* filled with water, in which a thermometer is placed.

For further detail as to the construction, calibration, and mode of operating with the apparatus, *see* Phil. Trans., 1872, p. 3.

In Fig. 5 a drawing is given of the whole apparatus as arranged for experiment.

FIG. 5.



2409a. Apparatus by which the body in the atmosphere which acts upon Schönbein's test-papers was first certainly proved to be identical with ozone. *Dr. Andrews, F.R.S.*

Atmospheric air, in fine weather and acting freely upon the test-papers, was drawn steadily through a glass globe, capable of being heated to 300° C., when all chemical reactions disappeared, which could only occur in the case of ozone.

2562. Hofmann's Vapour Density Apparatus. *Julius Schober, Berlin.*

2411. Apparatus for rapidly saturating a small quantity of a liquid with a gas. Rough model. *George Gore, F.R.S.*

2412. Apparatus for rapidly saturating a small quantity of a liquid with a gas. *George Gore, F.R.S.*

2413. Apparatus for preparing small quantities of liquid carbonic acid gas, or liquid hydrochloric acid gas, and examining its action upon various substances. *George Gore, F.R.S.*

(Philosophical Transactions of the Royal Society, 1861, and Proceedings of the Royal Society, May 1865.)

2414. Apparatus for preparing small quantities of liquefied cyanogen or liquefied ammonia gases, and examining their action upon various substances. *George Gore, F.R.S.*

(Proceedings of the Royal Society, Vol. 20, p. 67 ; also No. 141, 1873.)

2415. Rod of Selenium, eight feet high, used in some experiments upon light. *George Gore, F.R.S.*

2419. One hundred and eleven vessels and **articles** of **Platinum** (weight 117¼ ounces), used in Researches on Anhydrous Hydrofluoric acid and the Fluorides.

George Gore, F.R.S.

2419a. Pure Fluorides in bottles of platinum, &c., used in researches on the Fluorides. *George Gore, F.R.S.*

Four platinum bottles containing pure fluorides of sodium, cerium, manganese, and bismuth.

Four gutta-percha bottles containing fluorides of glucinum, thallium, and cadmium, and the double fluoride of hydrogen and potassium.

Two glass bottles containing fluorides of lithium and rubidium.

Used in researches on the fluorides. (See Philosophical Transactions of the Royal Society, 1869.)

2419b. Specimen of Alibert's Native Graphite, from Mount Batougal, Irkoutsk, Siberia. *George Gore, F.R.S.*

2419c. Bottles (53) containing Fluorides used in researches on the Fluorides. *George Gore, F.R.S.*

37 gutta-percha bottles, 12 glass ditto, and 4 platinum ditto, containing various pure fluorides used in researches on anhydrous hydrofluoric acid and the fluorides. (See Philosophical Transactions of the Royal Society, 1869.)

2419d. Vessels and Articles (35) of baked and fused fluoride, cryolite, fluor-spar, native graphite, gas carbon, and wood charcoal, for researches on Fluorides. *George Gore, F.R.S.*

13 boats formed of baked and fused fluorides.
6 ,, ,, ,, fluoride of calcium.
5 ,, ,, fluor-spar.
2 ,, ,, cryolite.
1 ,, ,, native graphite.
1 ,, ,, wood charcoal.
1 tube ,, ,,
1 crucible ,, gas carbon.
1 cup ,, ,,
4 plates ,, polished fluor-spar.

All these articles for use in researches on the fluorides. (See Philosophical Transactions of the Royal Society, 1869.)

2419e. Three Specimens of Melted Silicon in bottle.
George Gore, F.R.S.

2419f. Vessels and Articles of wood-charcoal, native graphite, and gas carbon, used in researches on the Fluorides.
George Gore, F.R.S.

11 crucibles of wood charcoal, in bottle.
9 boats of native graphite, in box.
2 rods of lignum vitæ charcoal.
1 boat of gas carbon.

Used in researches on the fluorides. (See Philosophical Transactions of the Royal Society, 1869, &c.)

2419g. Glass Vessel for **collecting** and **Measuring Gases.**
George Gore, F.R.S.

2419h. Glass Beehive Shelf used in **collecting Gases.**
George Gore, F.R.S.

2419i. Specimens of Native Rock Salt from Jhelum, in Cabul, Affghanistan; Wiclicska, in Poland; and Erfurt, in Prussia. *George Gore, F.R.S.*

2419k. Specimens of Native Iron. *George Gore, F.R.S.*

2419l. Specimens of Native Antimony.
George Gore, F.R.S.

2421. Pseudo-crystal of **Native Ceylon Graphite. Bar** of extremely pure **metallic Tellurium,** weighing 2,000 grains.
George Gore, F.R.S.

2431. Collection of Vanadium Compounds.
Prof. H. E. Roscoe, F.R.S.

1. Vanadium ore, containing 2 per cent. vanadium.
2. Roasted vanadium ore.
3. Ammonium meta-vanadate (3rd crystallization).
4. Pure vanadium pentoxide, V_2O_5.
5. Vanadium tetroxide, V_2O_4.
6. Vanadium trioxide, V_2O_3.
7. Vanadium pentoxide, containing phosphorus.

8. Vanadium mononitride, VN.
9. Vanadium platinum alloy.
10. Vanadium silicon alloy.
11. Ammonium meta-vanadate (pure), NH_4VO_3.
12. Lead meta-vanadate, $Pb2VO_3$.
13. Di-vanadyl monochloride, V_2O_2Cl.
14. Vanadium tetrachloride (VCl_4) decomposed into vanadium trichloride (VCl_3) and Chlorine (Cl).
15. Vanadous sulphate.
16. Copper sulphate.
17. Potassium anhydro-chromate.
18. Potassium anhydro-vanadate.
19. Sodium ortho-vanadate, $Na_3VO_4+16H_2O$.
20. Sodium ortho-vanadate (fused mass).
21. Artificial vanadinite $3(Pb_3V_2O_8)+PbCl_2$.
22. Fused mass of artificial vanadinite.
23. Silver ortho-vanadate, Ag_3VO_4.
24. Sodium pyro-vanadate, $Na_4V_2O_7+18H_2O$.
25. Sodium pyro-vanadate, crystallized from alcohol.
26. Barium pyro-vanadate, $Ba_2V_2O_7$.
27. Basic pyro-vanadate of lead $2(Pb_2V_2O_7)+PbO$.
28. Silver pyro-vanadate, $Ag_4V_2O_7$.
29. Meta-vanadic acid, HVO_3.
30. Ammonium meta-vanadate NH_4VO_3 (crystallized).
31. Sodium anhydro-vanadate $2(NaVO_3)+V_2O_5$ (v. Hauer).
32. Calcium di-vanadate, $Ca2VO_3+V_2O_5+18H_2O$ (v. Hauer).
33. Vanadium metal, $V=51\cdot3$.
34. Pure vanadium pentoxide. From $VOCl_3$.
35. Vanadium nitride, VN. From metal and VCl_4.
36. Vanadium nitride, VN. From pure VCl_2.
37. Vanadium nitride, VN. From V_2O_3.
38. Vanadium nitride, VN. From NH_4VO_3.
39. Vanadyl dichloride, $VOCl_2$.
40. Vanadium sesquioxide, undergoing oxidation.
41. Ammonium magnesium phosphate. From Berzelius's vanadium (1831).
42. Thallium tetra-vanadate, $Tl_{12}V_4O_{16}$ (or $4Tl_3VO_4$).
43. Thallium hexa-vanadate, $Tl_{12}V_6O_{21}$.
44. Thallium octa-vanadate, $Tl_{12}V_8O_{26}$.
45. Silver octa-vanadate, $Ag_{12}V_8O_{26}$.
46. Sodium octa-vanadate, $Na_{12}V_8O_{26}$.
47. Thallium deca-vanadate, $Tl_{12}V_{10}O_{31}$.
48. Thallium dodeca-vanadate, $Tl_{12}V_{12}O_{36}$.
49. Thallium tetra-kai-deca-vanadate, $Tl_{12}V_{14}O_{41}$.
50. Vanadium metal, $V=51\cdot3$.
51. Vanadium oxidibromide, $VOBr_2$.

52. VCl_4 decomposed into $VCl_3 + Cl$.
53. Vanadium oxitrichloride, $VOCl_3$.
54. VCl_4 undergoing decomposition.
55. Vanadium dichloride, VCl_2.
56. Vanadium trichloride, VCl_3.
57. Vanadium pentoxide, V_2O_5.
58. V_2O_5.
59. V_2O_4 by reduction with SO_2.
60. V_2O_3 „ „ Mg.
61. V_2O_2 „ „ Na or Zn.

Solutions of the oxides in sulphuric acid.

62. $VOCl_3$
63. VCl_4
64. VCl_3
65. VCl_2

Obtained by throwing these compounds into water.

2423. Mercury Distilling Apparatus, constructed according to Dr. A. Weinhold's system.

J. Bosscha, Professor, Royal Polytechnic School, Delft.

(Carl's Repertorium der Physik, vol. ix., p. 69), with slight modifications of the mercury reservoirs, giving per hour about 500 grammes of distilled mercury, constructed by M. M. P. J. Kipp and Sons, Delft.

2425. The **Original Air Battery.**

J. H. Gladstone and Alfred Tribe.

When a plate of copper is connected with metallic silver, and immersed in a solution of copper nitrate, the oxygen of the air dissolved in the liquid takes part in the re-action, the copper is eaten away, and cuprous oxide is deposited upon the silver. This gives rise to the ordinary voltaic phenomena.

2426. The **Original Copper-Zinc Couple.** A.D. 1871.

J. H. Gladstone and Alfred Tribe.

This consists of coils of sheet-zinc on which copper has been deposited in a finely divided condition, by pouring copper sulphate upon them, and washing away the salt produced. In this case the coils are separated by layers of muslin. The couple having been immersed in water, has decomposed it, and the zinc is now thoroughly oxidized.

2427. The **Original Copper-zinc Couple** of the present arrangement. *J. H. Gladstone and Alfred Tribe.*

In this case the zinc foil is crumpled, and covered with the deposited copper. The zinc is now completely covered with oxide through the decomposition of water.

2428. Tubes showing that the hydrogen prepared from water by the copper-zinc couple does not contain arsenic, though the zinc is so greatly contaminated with arsenic as to give much arseniuretted hydrogen when dissolved in acid.

J. H. Gladstone and Alfred Tribe.

2429. Original Specimens of Ethylo-bromide of Zinc, and **Ethylo-chloride of Zinc,** substances prepared by means of the copper-zinc couple. *J. H. Gladstone and Alfred Tribe.*

2430. Essential Oils and their derivatives. *J. H. Gladstone.*

1. Menthene. An oil of the $C_{10} H_{16}$ group.
2. Cedrene. An oil of the $C_{15} H_{24}$ group.
3. Hydrosulphate of menthole.
4. Hydrate of oil of turpentine. $C_{10} H_{16}, 3H_2O$.
5. The same recrystallized from water.
6. Cœruleine, a deep blue colouring matter found in the essential oils of Matricaria Chamomilla, Artemisia Absinthium, and several others of the $C_{15} H_{24}$ group.

2430a. Specimens of **Chemicals illustrating Researches** on :—

1. The transformation of cyanogen (CN) into oxatyl (COHo).
2. Polymerisation of ethylic cyanide.
3. The isolation of the organic radicals.
4. Organo-metallic bodies.
5. The substitution of $'N_2''$ for C^{iv} in organic compounds.
6. Organo-boron compounds.
7. The synthesis of ethers, acids of the acetic series, and ketones.
8. The synthesis of acids of the lactic series.
9. The synthesis of acids of the acrylic series.

E. Frankland, F.R.S.

I.—TRANSFORMATION OF CYANOGEN (CN) INTO OXATYL (COHo) IN ORGANIC COMPOUNDS.—(Kolbe & Frankland.)

1. Acetic acid $\left(\left\{\begin{matrix}\mathbf{C}H_3\\ \mathbf{C}OHo\end{matrix}\right.\right)$ made from β methylic cyanide $\left(\left\{\begin{matrix}\mathbf{C}H_3\\ \mathbf{C}N\end{matrix}\right.\right)$.

2. Argentic acetate $\left(\left\{\begin{matrix}\mathbf{C}H_3\\ \mathbf{C}OAgo\end{matrix}\right.\right)$ made from the above acid.

3. Propionic acid $\left(\left\{\begin{matrix}\mathbf{C}MeH_2\\ \mathbf{C}OHo\end{matrix}\right.\right)$ made from β ethylic cyanide $\left(\left\{\begin{matrix}\mathbf{C}MeH_2\\ \mathbf{C}N\end{matrix}\right.\right)$.

The following salts made from this acid :—

4. Argentic propionate $\left(\left\{\begin{matrix}\mathbf{C}MeH_2\\ \mathbf{C}OAgo\end{matrix}\right.\right)$.

5. Baric propionate $\begin{matrix}\left\{\begin{matrix}\mathbf{C}MeH_2\\ \mathbf{C}O\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}O\\ \mathbf{C}MeH_2\end{matrix}\right.\end{matrix}Bao''$.

6. Plumbic propionate $\begin{matrix}\left\{\begin{matrix}\mathbf{C}MeH_2\\ \mathbf{C}O\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}O\\ \mathbf{C}MeH_2\end{matrix}\right.\end{matrix}Pbo''$.

7. Caproic acid $\left(\left\{\begin{matrix}\mathbf{C}BuH_2\\ \mathbf{C}OHo\end{matrix}\right.\right)$ made from β amylic cyanide $\left\{\begin{matrix}\mathbf{C}BuH_2\\ \mathbf{C}N\end{matrix}\right.$.

The following salts made from this acid :—

8. Argentic caproate $\left\{\begin{matrix}\mathbf{C}BuH_2\\ \mathbf{C}OAgo\end{matrix}\right.$.

9. Baric caproate $\begin{matrix}\left\{\begin{matrix}\mathbf{C}BuH_2\\ \mathbf{C}O\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}O\\ \mathbf{C}BuH_2\end{matrix}\right.\end{matrix}Bao''$.

II.—Polymerisation of Ethylic Cyanide.—(Kolbe & Frankland.)

1. Cyanethine $^{vi}(\mathbf{N}_3)^{ix}\,(CEt)'''_3$.
2. Cyanethine nitrate $\mathbf{N}O_2(N_3C_9H_{16}O)$.
3. Cyanethine oxalate $\left\{\begin{matrix}\mathbf{C}O(N_3C_9H_{16}O)\\ \mathbf{C}O(N_3C_9H_{16}O)\end{matrix}\right.$.
4. Cyanethine platinic chloride $2N_3C_9H_{16}Cl,\ PtCl_4$.

III.—Isolation of the Organic Radicals.—(Frankland.)

1. Methyl $\left\{\begin{matrix}\mathbf{C}H_3\\ \mathbf{C}H_3\end{matrix}\right.$ or Me_2.
2. Ethyl $\left\{\begin{matrix}\mathbf{C}MeH_2\\ \mathbf{C}MeH_2\end{matrix}\right.$ or Et_2.
3. Ethylic hydride $\mathbf{C}MeH_3$ or EtH.
4. Amyl $\left\{\begin{matrix}\mathbf{C}BuH_2\\ \mathbf{C}BuH_2\end{matrix}\right.$ or Ay_2.
5. Amylic hydride $CBuH_3$ or AyH.
6. Eudiometer in which ethyl was first analysed.

IV.—Organo-metallic Bodies.—(Frankland).

1. Zincic methide	$\mathbf{Zn}Me_2$.
2. Zincic ethide	$\mathbf{Zn}Et_2$.
3. Zincic ethylate	$\mathbf{Zn}Eto_2$.
4. Zincic amylide	$\mathbf{Zn}Ay_2$.
5. Stannous ethide	$\mathbf{Sn}Et_2$.
6. Stannic ethide	$\mathbf{Sn}Et_4$.
7. Stannic ethylo-dimethide	$\mathbf{Sn}Et_2Me_2$.
8. Stannic dichlorethide	$\mathbf{Sn}Et_2Cl_2$.
9. Stannic iodo-diethide	$\mathbf{Sn}Et_2I_2$.
10. Stannic bromo-triethide	$\mathbf{Sn}Et_3Br$.
11. Distannic iodo-tetrethide	$\mathbf{Sn}_2Et_4I_2$.
12. Mercuric methide	$\mathbf{Hg}Me_2$.
13. Mercuric iodomethide	$\mathbf{Hg}MeI$.
14. Mercuric chlormethide	$\mathbf{Hg}MeCl$.
15. Mercuric ethide	$\mathbf{Hg}Et_2$.
16. Mercuric chlorethide	$\mathbf{Hg}EtCl$.
17. Mercuric amylide	$\mathbf{Hg}Ay_2$.
18. Mercuric chloramylide	$\mathbf{Hg}AyCl$.
19. Mercuric iodoamylide	$\mathbf{Hg}AyI$.

V.—The Substitution of $'N_2''$ for C^{iv} in Organic Compounds.—(Frankland.)

1. Ethylozincic dinitroethylate $\mathbf{N}_2EtO(OZnEt)$.
2. Zincic dinitroethylate $\begin{matrix}\mathbf{N}_2EtO\\ \mathbf{N}_2EtO\end{matrix}Zno''$ analogous to zincic propionate $\begin{matrix}\mathbf{C}EtO\\ \mathbf{C}EtO\end{matrix}Zno''$.
3. Calcic dinitroethylate $\begin{matrix}\mathbf{N}_2EtO\\ \mathbf{N}_2EtO\end{matrix}Cao''$ analogous to calcic propionate $\begin{matrix}\mathbf{C}EtO\\ \mathbf{C}EtO\end{matrix}Cao''$.

4. Baric dinitroethylate $\begin{matrix}\mathbf{N}_2\mathrm{EtO}\\ \mathbf{N}_2\mathrm{EtO}\end{matrix}\mathrm{Bao}''$.

5. Magnesic dinitroethylate $\begin{matrix}\mathbf{N}_2\mathrm{EtO}\\ \mathbf{N}_2\mathrm{EtO}\end{matrix}\mathrm{Mgo}''$.

6. Cupric dinitroethylate $\begin{matrix}\mathbf{N}_2\mathrm{EtO}\\ \mathbf{N}_2\mathrm{EtO}\end{matrix}\mathrm{Cuo}''$.

7. Sodic dinitroethylate $\mathbf{N}_2\mathrm{EtONao}$ analogous to sodic propionate $\mathbf{C}\mathrm{EtONao}$.

VI.—ORGANO-BORON COMPOUNDS.—(Frankland.)

1. Boric methide $\mathbf{B}\mathrm{Me}_3$.
2. Ammonia-boric methide $\mathbf{N}\mathrm{H}_3$, $\mathbf{B}\mathrm{Me}_3$.
3. Boric ethide $\mathbf{B}\mathrm{Et}_3$.
4. Ammonia boric ethide $\mathbf{N}\mathrm{N}_3$, $\mathbf{B}\mathrm{Et}_3$.
5. Boric etho-diethylate $\mathbf{B}\mathrm{EtEto}_2$.
6. Boric etho-dihydrate $\mathbf{B}\mathrm{EtHo}_2$.

VII.—SYNTHESIS OF ETHERS, ACIDS OF THE ACETIC SERIES AND KETONES.—(Frankland & Duppa.)

Ethers.

1. Ethylic methaceto-acetate $C_7H_{12}O_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{MeH}.\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$

2. Ethylic dimethaceto-acetate $C_8H_{14}O_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{Me}_2.\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$

3. Ethylic ethaceto-acetate $C_8H_{14}O_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{EtH}.\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$

4. Ethylic diethaceto-acetate $C_{10}H_{18}O_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{Et}_2.\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$

5. Ethylic isopropaceto-acetate $C_9H_{16}O_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\beta\mathrm{PrH}.\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$

6. Ethylic dimethacetate (isobutyrate) $C_6H_{12}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Me}_2\mathrm{H}\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.

7. Ethylic ethacetate (butyrate) $C_6H_{12}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{EtH}_2\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.

8. Ethylic diethacetate (isocaproate) $C_8H_{16}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et}_2\mathrm{H}\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.

9. Ethylic isopropacetate (isovalerate) $C_7H_{14}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\beta\mathrm{PrH}_2\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.

10. Ethylic amylacetate (œnanthylate) $C_9H_{18}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{AyH}_2\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.

Acids and their Salts.

1. Dimethacetic acid (isobutyric acid) $C_4H_8O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Me}_2\mathrm{H}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

2. Argentic dimethacetate $C_4H_7AgO_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Me}_2\mathrm{H}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right.$.

3. Ethacetic acid (butyric acid) $C_4H_8O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{EtH_2}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

4. Argentic ethacetate $C_4H_7AgO_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{EtH_2}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right.$.

5. Diethacetic acid (isocaproic acid) $C_6H_{12}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2H}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

6. Argentic diethacetate $C_6H_{11}AgO_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2H}\\ \mathbf{C}\mathrm{OAge}\end{array}\right.$.

7. Baric diethacetate $C_{12}H_{22}BaO_4$ or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2H}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Et_2H}\end{array}\right.\end{array}\mathrm{Bao''}$.

8. Isopropacetic acid (isovaleric acid) $C_5H_{10}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\beta\mathrm{PrH_2}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

9. Argentic isopropacetate $C_5H_9AgO_2$ or $\left\{\begin{array}{l}\mathbf{C}\beta\mathrm{PrH_2}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right.$

10. Amylacetic acid (œnanthylic acid) $C_7H_{14}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{AyH_2}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

11. Argentic amylacetate $C_7H_{13}AgO_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{AyH_2}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right.$.

12. Baric amylacetate $C_{14}H_{26}BaO_4$ or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{AyH_2}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{AyH_2}\end{array}\right.\end{array}\mathrm{Bao''}$.

Ketones.

1. Methylated acetone C_4H_8O or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{MeH_2}\end{array}\right.$.

2. Dimethylated acetone $C_5H_{10}O$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{Me_2H}\end{array}\right.$.

3. Ethylated acetone $C_5H_{10}O$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{EtH_2}\end{array}\right.$.

4. Diethylated acetone $C_7H_{14}O$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\mathrm{Et_2H}\end{array}\right.$.

5. Isopropylated acetone $C_6H_{12}O$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{OMe}\\ \mathbf{C}\beta\mathrm{PrH_2}\end{array}\right.$.

VIII.—SYNTHESIS OF ACIDS OF THE LACTIC SERIES.—(Frankland & Duppa.)

1. Dimethoxalic acid $C_4H_8O_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Me_2Ho}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

2. Argentic dimethoxalate $C_4H_7AgO_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Me_2Ho}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right.$.

3. Baric dimethoxalate $C_8H_{14}BaO_6$ or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{Me_2Ho}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Me_2Ho}\end{array}\right.\end{array}\mathrm{Bao''}$.

4. Ethomethoxalic acid $C_5H_{10}O_3$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{EtMeHo}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

5. Argentic ethomethoxalate	$C_5H_9AgO_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{EtMeHo}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right.$.
6. Ethylic ethomethoxalate	$C_7H_{14}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{EtMeHo}\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.
7. Baric ethomethoxalate	$C_{10}H_{18}BaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{EtMeHo}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{EtMeHo}\end{array}\right.\end{array}\mathrm{Bao''}$.
8. Diethoxalic acid	$C_6H_{12}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.
9. Argentic diethoxalate	$C_6H_{11}AgO_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right., \frac{1}{2}\mathbf{O}\mathrm{H}_2$.
10. Methylic diethoxalate	$C_7H_{14}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{OMeo}\end{array}\right.$.
11. Ethylic diethoxalate	$C_8H_{16}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.
12. Amylic diethoxalate	$C_{11}H_{22}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{OAyo}\end{array}\right.$.
13. Baric diethoxalate	$C_{12}H_{22}BaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Et_2Ho}\end{array}\right.\end{array}\mathrm{Bao''}$.
14. Cupric diethoxalate	$C_{12}H_{22}CuO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Et_2Ho}\end{array}\right.\end{array}\mathrm{Cuo''}$.
15. Zincic diethoxalate	$C_{12}H_{22}ZnO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2Ho}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Et_2Ho}\end{array}\right.\end{array}\mathrm{Zno''}$.
16. Ethylic zincmonethyl diethoxalate	$C_{10}H_{20}ZnO_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et_2(OZnEt)}\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.
17. Amylhydroxalic acid	$C_7H_{14}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{AyHHo}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.
18. Ethylic amylhydroxalate	$C_9H_{18}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{AyHHo}\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.
19. Calcic amylhydroxalate	$C_{14}H_{26}CaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{AyHHo}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{AyHHo}\end{array}\right.\end{array}\mathrm{Cao''}$.
20. Baric amylhydroxalate	$C_{14}H_{26}BaO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{AyHHo}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{AyHHo}\end{array}\right.\end{array}\mathrm{Bao''}$.
21. Cupric amylhydroxalate	$C_{14}H_{26}CuO_6$	or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{AyHHo}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{AyHHo}\end{array}\right.\end{array}\mathrm{Cuo''}$.
22. Amylethoxalic acid	$C_9H_{18}O_3$	or $\left\{\begin{array}{l}\mathbf{C}\mathrm{AyEtHo}\\ \mathbf{C}\mathrm{OHo}\end{array}\right.$.

23. Argentic amylethoxalate	$C_9H_{17}AgO_3$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{AyEtHo}\\ \mathbf{C}\mathrm{OAgo}\end{matrix}\right.$.
24. Ethylic amylethoxalate	$C_{11}H_{22}O_3$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{AyEtHo}\\ \mathbf{C}\mathrm{OEto}\end{matrix}\right.$.
25. Baric amylethoxalate	$C_{18}H_{34}BaO_6$	or	$\begin{matrix}\left\{\begin{matrix}\mathbf{C}\mathrm{AyEtHo}\\ \mathbf{C}\mathrm{O}\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{AyEtHo}\end{matrix}\right.\end{matrix}\mathrm{Bao}'$.
26. Diamyloxalic acid	$C_{12}H_{24}O_3$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Ay_2Ho}\\ \mathbf{C}\mathrm{OHo}\end{matrix}\right.$.
27. Ethylic diamyloxalate	$C_{14}H_{28}O$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Ay_2Ho}\\ \mathbf{C}\mathrm{OEto}\end{matrix}\right.$.
28. Amylic diamyloxalate	$C_{17}H_{34}O_3$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Ay_2Ho}\\ \mathbf{C}\mathrm{OAyo}\end{matrix}\right.$.
29. Baric diamyloxalate	$C_{24}H_{46}BaO_3$	or	$\begin{matrix}\left\{\begin{matrix}\mathbf{C}\mathrm{Ay_2Ho}\\ \mathbf{C}\mathrm{O}\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Ay_2Ho}\end{matrix}\right.\end{matrix}\mathrm{Bao}''$.

IX.—SYNTHESIS OF ACIDS OF THE ACRYLIC SERIES.—(Frankland & Duppa.)

1. Methacrylic acid	$C_4H_6O_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Me''Me}\\ \mathbf{C}\mathrm{OHo}\end{matrix}\right.$.
2. Argentic methacrylate	$C_4H_5AgO_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Me''Me}\\ \mathbf{C}\mathrm{OAgo}\end{matrix}\right.$.
3. Ethylic methacrylate	$C_6H_{10}O_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Me''Me}\\ \mathbf{C}\mathrm{OEto}\end{matrix}\right.$.
4. Baric methacrylate	$C_8H_{10}BaO_4$	or	$\begin{matrix}\left\{\begin{matrix}\mathbf{C}\mathrm{Me''Me}\\ \mathbf{C}\mathrm{O}\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Me''Me}\end{matrix}\right.\end{matrix}\mathrm{Bao}'$.
5. Cupric methacrylate	$C_8H_{10}CuO_4$	or	$\begin{matrix}\left\{\begin{matrix}\mathbf{C}\mathrm{Me''Me}\\ \mathbf{C}\mathrm{O}\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Me''Me}\end{matrix}\right.\end{matrix}\mathrm{Cuo}''$.
6. Methyl-crotonic acid	$C_5H_8O_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Et''Me}\\ \mathbf{C}\mathrm{OHo}\end{matrix}\right.$.
7. Argentic methyl-crotonate	$C_5H_7AgO_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Et''Me}\\ \mathbf{C}\mathrm{OAgo}\end{matrix}\right.$.
8. Ethylic methyl-crotonate	$C_7H_{12}O_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Et''Me}\\ \mathbf{C}\mathrm{OEto}\end{matrix}\right.$.
9. Baric methyl-crotonate	$C_{10}H_{14}BaO_4$	or	$\begin{matrix}\left\{\begin{matrix}\mathbf{C}\mathrm{Et''Me}\\ \mathbf{C}\mathrm{O}\end{matrix}\right.\\ \left\{\begin{matrix}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Et''Me}\end{matrix}\right.\end{matrix}\mathrm{Bao}''$.
10. Ethyl-crotonic acid	$C_6H_{10}O_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Et''Et}\\ \mathbf{C}\mathrm{OHo}\end{matrix}\right.$.
11. Potassic ethyl-crotonate	$C_6H_9KO_2$	or	$\left\{\begin{matrix}\mathbf{C}\mathrm{Et''Et}\\ \mathbf{C}\mathrm{OKo}\end{matrix}\right.$.

12. Argentic ethyl-crotonate $C_6H_9AgO_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et''Et}\\ \mathbf{C}\mathrm{OAgo}\end{array}\right.$.

13. Ethylic ethyl-crotonate $C_8H_{14}O_2$ or $\left\{\begin{array}{l}\mathbf{C}\mathrm{Et''Et}\\ \mathbf{C}\mathrm{OEto}\end{array}\right.$.

14. Cupric ethyl-crotonate $C_{12}H_{18}CuO_4$ or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{Et''Et}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Et''Et}\end{array}\right.\end{array}\mathrm{Cuo''}$.

15. Plumbic ethyl-crotonate $C_{12}H_{18}PbO_4$ or $\begin{array}{l}\left\{\begin{array}{l}\mathbf{C}\mathrm{Et''Et}\\ \mathbf{C}\mathrm{O}\end{array}\right.\\ \left\{\begin{array}{l}\mathbf{C}\mathrm{O}\\ \mathbf{C}\mathrm{Et''Et}\end{array}\right.\end{array}\mathrm{Pbo''}$.

2536. Specimens of **Chemicals,** illustrating some of W. H. Perkin's researches in organic chemistry.

W. H. Perkin, F.R.S.

I. On the action of chloride of cyanogen on naphthylamine.

II. On the action of bromine on acetic acid and artificial formation of glycocol. (Perkin and Duppa.)

III. On the action of bromine on bromacetic acid. (Perkin and Duppa.)

IV. On dibromosuccinic acid, and the artificial production of tartaric acid. (Perkin and Duppa.)

V. On azodinaphthyldiamin. (Perkin and Church.)

VI. On mauve or aniline purple.

VII. On the basicity of tartaric acid.

VIII. On some derivatives of the hydride of salicyl.

IX. On the action of acetic anhydride on the hydride of salicyl.

X. On the artificial production of coumarin and its homologues.

XI. On some new derivatives of coumarin.

XII. On chlorinated chloride of methyl.

XIII. On some derivatives of anthracene.

XIV. On artificial alizarin.

XV. On bromo-alizarin.

XVI. On nitro-alizarin.

XVII. On anthrapurpurin.

XVIII. On anthraflavic acid.

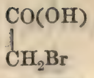
XIX. On the formation of anthrapurpurin.

XX. On glyoxylic acid.

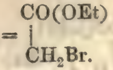
I.

Menaphthylamine (carbodinaphthyltriamine) $C_{21}H_{17}N_3$, product of the action of chloride of cyanogen on naphthylamine $C_{10}H_9N$.

II.

Bromacetic acid $C_2H_3BrO_2$ = 

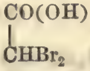
$$\begin{array}{l} CO(OH) \\ | \\ CH_2Br \end{array}$$

„ ether $C_4H_7BrO_2$ = 

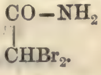
$$\begin{array}{l} CO(OEt) \\ | \\ CH_2Br. \end{array}$$

(Perkin and Duppa.)

III.

Dibromacetic acid $C_2H_2Br_2O_2$ – 

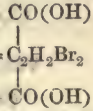
$$\begin{array}{l} CO(OH) \\ | \\ CHBr_2 \end{array}$$

Dibromacetamide $C_2H_3Br_2NO$ = 

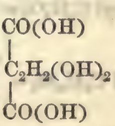
$$\begin{array}{l} CO-NH_2 \\ | \\ CHBr_2. \end{array}$$

(Perkin and Duppa.)

IV.

Dibromosuccinic acid $C_4H_4Br_2O_4$ =  prepared from the chloride of dibromosuccinyl.

$$\begin{array}{l} CO(OH) \\ | \\ C_2H_2Br_2 \\ | \\ CO(OH) \end{array}$$

Tartaric acid (inactive) $C_4H_6O_6, H_2O$ =  obtained by boiling argentic dibromosuccinate with water.

$$\begin{array}{l} CO(OH) \\ | \\ C_2H_2(OH)_2 \\ | \\ CO(OH) \end{array}$$

(Perkin and Duppa.)

V.

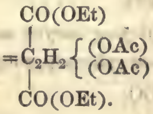
Azodinaphthyldiamin $C_{20}H_{15}N_3 = \left.\left\{\begin{array}{l} ((C_{10}H_7)_2) \\ N''' \\ H \end{array}\right.\right\} N_2.$

(Perkin and Church.)

VI.

Mauveine	$C_{27}H_{24}N_4$.
„ hydrochlorate	$C_{27}H_{24}N_4$—Cl.
„ sulphate	$(C_{27}H_{24}N_4)_2H_2SO_4$.
„ nitrate	$C_{27}H_{24}N_4HNO_3$.
„ hydriodate	$C_{27}H_{24}N_4HI$.
„ carbonate	$C_{27}H_{24}N_4H_2CO_3$?

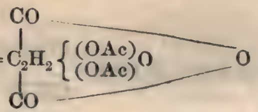
VII.

Diacetotartaric ether $C_{12}H_{18}O_8$ = 

$$\begin{array}{l} CO(OEt) \\ | \\ C_2H_2\left\{\begin{array}{l} (OAc) \\ (OAc) \end{array}\right. \\ | \\ CO(OEt). \end{array}$$

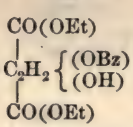
Diacetoparatartaric ether do. do.

Diacetotartaric anhydride $C_8H_8O_8=$



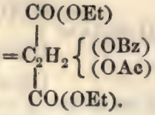
$$\begin{array}{ll} CO & \\ | & \\ C_2H_2\left\{\begin{matrix}(OAc)\\(OAc)\end{matrix}\right.O & O \\ | & \\ CO & \end{array}$$

Benzotartaric ether $C_{15}H_{18}O_7=$



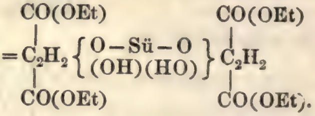
$$\begin{array}{l} CO(OEt) \\ | \\ C_2H_2\left\{\begin{matrix}(OBz)\\(OH)\end{matrix}\right. \\ | \\ CO(OEt)\end{array}$$

Acetobenzotartaric ether $C_{17}H_{20}O_8=$



$$\begin{array}{l} CO(OEt) \\ | \\ C_2H_2\left\{\begin{matrix}(OBz)\\(OAc)\end{matrix}\right. \\ | \\ CO(OEt).\end{array}$$

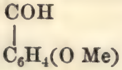
Succinotartaric ether $C_{20}H_{30}O_{14}=$



$$\begin{array}{lcl} CO(OEt) & & CO(OEt) \\ | & & | \\ C_2H_2 & \left\{\begin{matrix}O-Sü-O\\(OH)(HO)\end{matrix}\right\} & C_2H_2 \\ | & & | \\ CO(OEt) & & CO(OEt).\end{array}$$

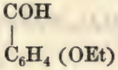
VIII.

Hydride of methylsalicyl $C_8H_8O_2=$



$$\begin{array}{l} COH \\ | \\ C_6H_4(O\ Me)\end{array}$$

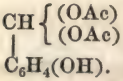
Hydride of ethylsalicyl $C_9H_{10}O_2=$



$$\begin{array}{l} COH \\ | \\ C_6H_4\ (OEt)\end{array}$$

IX.

Hydride of salicyl and acetic anhydride $C_{11}H_{12}O_5=$



$$\begin{array}{l} CH\left\{\begin{matrix}(OAc)\\(OAc)\end{matrix}\right. \\ | \\ C_6H_4(OH).\end{array}$$

X.

Coumarin $C_9H_6O_2$, artificially prepared from hydride of sodium-salicyl, and acetic anhydride. It is probably ortho-oxyphenyl acrylic anhydride $C_6H_4\left\{\begin{matrix}O\\C_2H_2\end{matrix}\right\}CO.$

Propionic coumarin, ortho-oxyphenylcrotonic anhydride
$C_{10}H_8O_2=C_6H_4\left\{\begin{matrix}O\\C_3H_4\end{matrix}\right\}CO,$
produced as above, but employing propionic anhydride.

Butyric coumarin, ortho-oxyphenylangelic anhydride
$C_{11}H_{10}O_2=C_6H_4\left\{\begin{matrix}O\\C_4H_6\end{matrix}\right\}CO,$
prepared as above, but employing butyric anhydride.

Valeric coumarin, ortho-oxyphenylpyroterebic anhydride (?)
$C_{12}H_{12}O_2=C_6H_4\left\{\begin{matrix}O\\C_5H_8\end{matrix}\right\}CO,$
prepared as above, but employing valeric anhydride.

XI.

α Bromocoumarin $C_9H_5BrO_2 = C_6H_4\left\{\begin{matrix}O\\ C_2HBr\end{matrix}\right\}CO.$

β Bromocoumarin $C_9H_5BrO_2 = C_6H_3Br\left\{\begin{matrix}O\\ C_2H_2\end{matrix}\right\}CO.$

α Dibromocoumarin $C_9H_4Br_2O_2 = C_6H_3Br\left\{\begin{matrix}O\\ C_2HBr\end{matrix}\right\}CO.$

β Dibromocoumarin $C_9H_4Br_2O_2 = C_6H_2Br_2\left\{\begin{matrix}O\\ C_2H_2\end{matrix}\right\}CO.$

α Chlorocoumarin $C_9H_5ClO_2 = C_6H_4\left\{\begin{matrix}O\\ C_2HCl\end{matrix}\right\}CO.$

Tetrachlorocoumarin $C_9H_2Cl_4O_2$.

Coumarilic acid $C_9H_6O_3 = C_6H_4\left\{\begin{matrix}O\\ C_2H(OH)\end{matrix}\right\}CO.$

Potassic coumarilate $C_9H_5KO_3 = C_6H_4\left\{\begin{matrix}O\\ C_2H(OK)\end{matrix}\right\}CO.$

Sulphocoumarilic acid $C_9H_6O_2SO_3 2H_2O$

Baric sulphocoumarilate $C_{18}H_{10}BaO_4S_2O_6 = 5H_2O$.

Baric disulphocoumarilate $C_9H_4BaO_2S_2O_6H_2O$.

Bromopropionic coumarin $C_{10}H_7BrO_2$.

XII.

Chlorinated chloride of methyl, dichloride of methylene CH_2Cl_2.

XIII.

Anthracene $C_{14}H_{10}$.
Dichloranthracene $C_{14}H_8Cl_2$.
Dibromanthracene $C_{14}H_8Br_2$.
Dichloranthracene combined with picric acid $C_{14}H_8Cl_2C_6H_3(NO_2)_3O$.
Sodic disulphodichloranthracenate $C_{14}H_6Cl_2\left\{\begin{matrix}NaSO_3\\ NaSO_3\end{matrix}\right.$.
Baric disulphodichloranthracenate $C_{14}H_6Cl_2Ba2SO_3$.
Strontic disulphodichloranthracenate $C_{14}H_6Cl_2Sr2SO_3$.
Baric disulphodibromanthracenate $C_{14}H_6Br_2Ba2SO_3$.
Anthraquinone $C_{14}H_8O_2$.
Baric disulphanthraquinonate $C_{14}H_6O_2Ba2SO_3$.

XIV.

Artificial alizarin $C_{14}H_8O_4 = C_6H_4\left\{\begin{matrix}CO\\ CO\end{matrix}\right\}C_6H_2(OH)_2.$

Acetyl alizarin $= C_{16}H_{10}O_5 = C_6H_4\left\{\begin{matrix}CO\\ CO\end{matrix}\right\}C_6H_2\left\{\begin{matrix}(OH)\\ (OAc)\end{matrix}\right..$

Diacetyl alizarin $= C_{18}H_{12}O_6 = C_6H_4\left\{\begin{matrix}CO\\ CO\end{matrix}\right\}C_6H_2(OAc)_2.$

XV.

Bromalizarin $C_{14}H_7BrO_4 = C_6H_4\left\{\begin{matrix}CO\\ CO\end{matrix}\right\}C_6HBr(OH)_2.$

Diacetylbromalizarin $C_{18}H_{11}BrO_6 = C_6H_4\left\{\begin{matrix}CO\\ CO\end{matrix}\right\}C_6HBr(OAc_2).$

XVI.

Nitroalizarin $C_{14}H_7(NO_2)O_4=C_6H_4\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H(NO_2)(OH)_2$.

Amidoalizarin $C_{14}H_7(NH_2)O_4=C_6H_4\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H(NH_2)(OH)_2$.

XVII.

Anthrapurpurin $C_{14}H_8O_5=C_6H_3(OH)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_2(OH)_2$.

Triacetylanthrapurpurin $C_{20}H_{14}O_8=C_6H_3(OAc)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_2(OAc)_2$.

XVIII.

Anthraflavic acid $=C_{14}H_8O_4=C_6H_3(OH)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_3(OH)$.

Baric anthraflavate $2C_{14}H_6BaO_4, 3H_2O$.

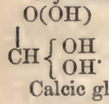
Diacetoanthraflavic acid $=C_{18}H_{12}O_6=C_6H_3(OAc)\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_3(OAc)$.

XIX.

New isomer of alizarin yielding anthrapurpurin on fusion with potassic hydrate $C_{14}H_8O_4$.

XX.

Crystallized glyoxylic acid obtained from dibromacetic acid $C_2H_4O_4=$



$$\begin{matrix}O(OH)\\|\\CH\left\{\begin{matrix}OH\\OH\end{matrix}\right.\end{matrix}$$

Calcic glyoxylate $C_4H_6Ca''O_4$.

2431a. 1. **Calorimeter,** by M. Berthelot, for thermo-chemical investigations, with electric mover of the agitator.

2. Air Thermometer, by M. Berthelot, glass, showing the temperature up to 550 degrees.

3. Air Thermometer, by M. Berthelot, silver, showing the temperature up to 900 degrees.

4. Apparatus for proving the disengagement of heat in the reaction of two gases.

5. Apparatus, by M. Berthelot, for the endothermic decomposition of formic acid by heat.

6. Two sealed globes, for the synthesis of formic acid by direct union of the oxide of carbon with potash, and sample of formate of lead, obtained by synthesis.

7. Apparatus, by M. Berthelot, for the synthesis of acetylene.

8. Bell glass, curved, in which was effected the synthesis of benzine, by the condensing of acetylene, by M. Berthelot; also another bell glass, empty.

9. Alcohol, obtained synthetically, by the union of olefiant gas with water.

10. Sealed tubes, containing organic matter, hydrogenized by iodhydric acid. *Laboratory of the College of France.*

2432. Series of Cryohydrates. *Frederick Guthrie.*

These are solutions of various salts in water, of such strengths that, when reduced below O° C. to the temperature marked on each flask, the salt and the water solidify together at that temperature. The same bodies in all cases result from the mixture of the respective salt with ice as a freezing mixture.

2433. Graphic Diagram, showing (1) the solubility of ice in the cryohydrates of various salts, (2) the composition of the cryohydrates and their melting points, (3) the solubility of the anhydrous salts in the cryohydrates and in water, (4) the temperature which the salt produces when used in a freezing mixture with ice or as an ice cryogen. *Frederick Guthrie.*

2435. Nitroxide of Amylen. *Frederick Guthrie.*

Discovered by the exhibitor. Of historical interest as being the first instance in which peroxide of nitrogen NO_2 was shown to behave as a halogen in uniting directly with an olefine to form a body homologous with "Dutch liquid." The composition of the body is $C_5H_{10}2NO_2$.

2436. Sulphide of Œnanthyl. *Frederick Guthrie.*

Discovered by the exhibitor, and of historical interest as being the first instance in which a term of a higher alcohol series was made from terms of lower alcohols. Formed by the action of zinc ethyl on sulpho-chloride of amylen.

2437. Nitrite of Amyl. *Frederick Guthrie.*

Discovered by M. Balard. Its therapeutic action discovered, and its introduction into the pharmacopœia recommended, by the exhibitor. Now coming into use in tetanic and other nervous affections.

2438. Collection of Preparations relating to chemical history of podocarpic acid (Annalen der Chemie und Pharmacie, vol. 170, p. 213). *Prof. A. C. Oudemans, Delft.*

2439. Hydrocarbons and Derivatives from Pennsylvania Petroleum. 23 specimens. *C. Schorlemmer, F.R.S.*

Group I.—Normal Paraffins.
  Pentane. Pentene. Pentyl chlorides.
  Hexane. Hexene. Hexyl chlorides. Hexyl acetates. Hexyl alcohols.
  Heptane. Heptene. Heptyl chlorides. Heptyl alcohols. Octane.
Group II.—Isoparaffins.
  Isopentane. Isohexane. Isoheptane.
Group III.—Aromatic Nitro-compounds.
  Dinitrobenzene. Dinitrotoluene,
  Nitro-compounds from fraction
    boiling at 110°—120°
      120°—130°
      130°—140° solid and liquid.
      140°—150°.

2440. Ethyl-Compounds, derived from dimethyl, which was obtained by the electrolysis of potassium acetate. Four specimens. *W. H. Darling.*

Ethyl chloride. Ethyl alcohol. Dichlorethane. Sodium Acetate.

2441. Aurin and Derivatives. 14 specimens.

C. Schorlemmer, F.R.S., and R. S. Dale, B.A.

Two specimens of commercial aurin.
Three specimens of pure aurin crystallised from alcohol.
Four specimens of pure aurin crystallised from acetic acid.
One specimen of the compound of aurin and sulphur dioxide.
One specimen of aurin-potassium sulphite.
One specimen of leucaurin.
One specimen of triacetyl-leucaurin.
One specimen of red aurin or peonin.

2485. Organic Compounds relating to the dry distillation of the "Galipot" resin, and to the constitution of pimaric acid (personal researches of the author). *Gustave Bruylants, Louvain.*

2486. Organic Compounds relating specially, 1° to the question of isomerism in glycerin derivatives; 2° to indicate the trialcoholic character of glycerin; 3° to show the reciprocal relations of allium compounds with glycerin compounds; 4° to propargylic compounds, and to the relations of allium compounds with propargylic compounds; 5° to binary compounds of allium; 6° to the binary propargylic compounds, and their relations with binary compounds of allium; 7° to the structure of the addition-products of hypochlorous acid.

Certain groups of these products are intended show: 8° the alcoholic character of alcohol acids, of basic ethers, and polyatomic alcohols, &c.; 9° the stability of the groupings Oxy-alcoholic Cn, H O in presence of PCl_5, PBr_5, &c., in opposition to the energetic reaction to which the corresponding hydro-oxygen compounds (O H) are subjected on the part of these re-agents, &c., and as a consequence the synthesis of oxalic acid, &c.

Louis Henry, Louvain.

2487. Mono-benzyl Urea, obtained by the action of ammonia on isocyanate of benzyl. Crystallized from water. (*See* Journal of Chemical Society, June 1872.)

$$\textit{Formula}\quad CO\left\{\begin{matrix} NHC_7H_7 \\ NH_2 \end{matrix}\right.$$

Dr. E. A. Letts and J. Fulton.

2488. Isocyanurate of Benzyl, obtained by the action of chloride of benzyl on cyanate of silver. Crystallized from alcohol. (*See* Journal of Chemical Society, June 1872.)

$$\textit{Formula}\quad (C_7H_7\text{—}NCO)_3$$

Dr. E. A. Letts and J. Fulton.

2489. Benzyl-phenyl Urea, obtained by the action of aniline on isocyanate of benzyl. The compound is unstable. (*See* Journal of Chemical Society, June 1872.)

$$\textit{Formula}\quad CO\left\{\begin{matrix} NHC_7H_7 \\ NHC_6H_5 \end{matrix}\right.$$

Dr. E. A. Leits and J. Fulton.

2490. Dibenzyl Urea, obtained by the action of water on isocyanate of benzyl. The specimen was crystallized from alcohol. (*See* Journal of Chemical Society, June 1872.)

Formula $CO\left\{\begin{matrix}NHC_7H_7\\NHC_7H_7\end{matrix}\right.$

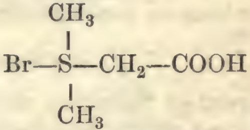
Dr. E. A. Letts and J. Fulton.

2491. Isocyanate of Benzyl mixed with chloride of benzyl, obtained by heating chloride of benzyl with cyanate of silver. The isocyanate of benzyl cannot be obtained in the pure condition, as it rapidly becomes polymerized into isocyanurate of benzyl. (*See* Journal of Chemical Society, June 1872.)

Formula of the isocyanate $C_7H_7-N=C=O$

Dr. E. A. Letts and J. Fulton.

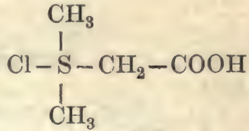
2492. Hydrobromate of Dimethyl Thetine, obtained by the action of sulphide of methyl on bromacetic acid. The specimen was crystallized from alcohol. (*See* Proceedings of Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)



Formula $\mathrm{Br{-}}\overset{\mathrm{CH_3}\atop |}{\underset{|\atop \mathrm{CH_3}}{\mathrm{S}}}\mathrm{{-}CH_2{-}COOH}$

Prof. A. Crum Brown and Dr. E. A. Letts.

2493. Hydrochlorate of Dimethyl Thetine, obtained by the action of chloride of barium on sulphate of dimethyl thetine. The specimen was separated from an aqueous solution by a mixture of alcohol and ether.

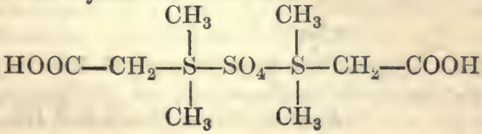


Formula $\mathrm{Cl{-}}\overset{\mathrm{CH_3}\atop |}{\underset{|\atop \mathrm{CH_3}}{\mathrm{S}}}\mathrm{{-}CH_2{-}COOH}$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Prof. A. Crum Brown and Dr. E. A. Letts.

2494. Sulphate of Dimethyl Thetine, obtained by the action of sulphate of silver on hydrobromate of dimethyl thetine. The specimen was crystallized from water.



Formula $\mathrm{HOOC{-}CH_2{-}}\overset{\mathrm{CH_3}\atop |}{\underset{|\atop \mathrm{CH_3}}{\mathrm{S}}}\mathrm{{-}SO_4{-}}\overset{\mathrm{CH_3}\atop |}{\underset{|\atop \mathrm{CH_3}}{\mathrm{S}}}\mathrm{{-}CH_2{-}COOH}$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Prof. A. Crum Brown and Dr. E. A. Letts.

2495. Poly-iodide of Dimethyl Thetine, obtained by the slow action of hydriodic acid on the base dimethyl thetine.

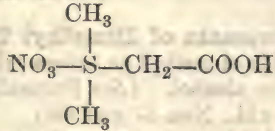
Not yet analysed.

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Prof. A. Crum Brown and Dr. E. A. Letts.

2496. Nitrate of Dimethyl Thetine, obtained by the action of nitrate of silver on hydrobromate of dimethyl thetine. The specimen was crystallized from alcohol.

Formula



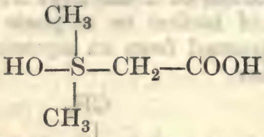
$$NO_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{S}}-CH_2-COOH$$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Prof. A. Crum Brown and Dr. E. A. Letts.

2497. Dimethyl Thetine, obtained by the action of water and oxide of silver on the hydrobromate of dimethyl thetine, or by the action of carbonate of barium on the sulphate. The base loses a molecule of water at 100° C.

Formula



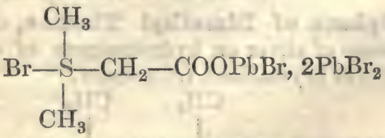
$$HO-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{S}}-CH_2-COOH$$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Prof. A. Crum Brown and Dr. E. A. Letts.

2498. Lead Salt of Hydrobromate of Dimethyl Thetine, obtained by the action of the latter on carbonate of lead. The specimen was crystallized from hot water.

Formula



$$Br-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{S}}-CH_2-COOPbBr,\ 2PbBr_2$$

(*See* Proceedings of the Royal Society of Edinburgh, vol. viii., Nos. 87 and 89.)

Prof. A. Crum Brown and Dr. E. A. Letts.

2499. Glass Digester in which to heat substances under pressure.

The apparatus consists of a well-annealed glass cylinder, closed at one end and drawn out at the other to a tube. Its capacity is about 600 cubic centimetres; the thickness of its walls about $\frac{1}{2}$ an inch throughout. The tube forming the neck is about $\frac{1}{6}$ of an inch in bore, and is closed by an accurately ground glass plate. The glass cylinder is mounted in a framework of brass, provided with a screw, which when turned presses the glass plate tightly against the tube, and thus hermetically closes the digester. The apparatus has been employed in the preparation of bromacetic acid, and large quantities of that substance have been prepared by its aid. The digester is intended as a substitute for sealed tubes, and has the great advantage over these that large quantities of substance can be heated at one operation, and that the danger of unsealing is avoided.

The apparatus is heated in an oil bath. *Dr. E. A. Letts.*

2500. Methyl-Sulphate of Calcium.
Dr. E. A. Letts and C. Abraham.

2501. Methyl-sulphate of Zinc.
Dr. E. A. Letts and C. Abraham.

2502. Methyl-sulphate of Ammonium.
Dr. E. A. Letts and C. Abraham.

2503. Specimens of Acetamide, Butyramide, Isobutyramide, and Valeramide; also of Valero-nitrile and Benzo-nitrile. These have been obtained by the action of the corresponding acids on sulphocyanate of potash, according to the equation

$$R-COOH+KCNS=HCNS+R-COOK.$$
$$R—COOH+HCNS=COS\ +R-CONH_2$$
$$R-COOH+HCNS=H_2S+CO_2+R-CN.$$

(In the case of the fatty acids the amide is the principal product, whilst the nitrile alone appears to be produced from the acid of the aromatic series. The process is easily and rapidly performed, and the yield good in all cases.

(*See* Proceedings of the Royal Society, No. 140, 1873.)
Dr. E. A. Letts and R. S. Marsden.

2504. Hyposulphite of Copper, Ammonium and Sodium, obtained by mixing a strong solution of hyposulphite of soda with ammonio-sulphate of copper. The salt separates from the solution spontaneously. Its formula is doubtful.
Dr. E. A. Letts and W. J. Nicol.

2505. Hyposulphite of Magnesium, obtained from hyposulphite of strontium by double decomposition with sulphate of magnesia, and subsequent evaporation of the solution on a water bath.

Formula $Mg\,S_2\,O_3, 6\,H_2\,O$.

Dr. E. A. Letts and W. J. Nicol.

2506. Hyposulphite of Strontium, obtained by mixing hot concentrated solutions of hyposulphite of soda and chloride of strontium. The salt separates spontaneously from the solution.

Formula $Sr\,S_2\,O_3, 5\,H_2\,O$.

Dr. E. A. Letts and W. J. Nicol.

2507. Hyposulphite of Barium, obtained by mixing solutions of hyposulphite of soda and chloride of barium.

Formula $Ba\,S_2\,O_3, H_2\,O$.

Dr. E. A. Letts and W. J. Nicol.

2508. Hyposulphite of Nickel, obtained from hyposulphite of strontium by double decomposition with sulphate of nickel, and subsequent evaporation of the solution in vacuo. The salt readily decomposes.

Formula $Ni\,S_2\,O_3, 6\,H_2\,O$.

Dr. E. A. Letts and W. J. Nicol.

2509. Hyposulphite of Cobalt, obtained from hyposulphite of strontium by double decomposition with sulphate of cobalt, and subsequent evaporation of the solution in vacuo. The salt readily decomposes.

Formula $Co\,S_2\,O_3, 6H_2\,O$.

Dr. E. A. Letts and W. J. Nicol.

2510. Liquid Hydrochlorate of Turpentine, distilled over with water vapour, and dried with chloride of calcium.

Formula $C_{10}\,H_{16}\,HCl$.

Dr. E. A. Letts.

2511. Solid Hydrochlorate of Turpentine, crystallized from alcohol.

Formula $C_{10}\,H_{16}\,HCl$.

Dr. E. A. Letts.

2512. Hydrate of Turpentine (Terpene), crystallized from water.

Formula $C_{10}\,H_{16}\,2H_2\,O$.

Dr. E. A. Letts and James Davidson.

2513. Hydrate of Hydrocarbon contained in Oil of Lavender (exotic); obtained by allowing a mixture of the oil with dilute alcohol and nitric acid to remain for some weeks at rest. The specimen was crystallized from water. Not yet analysed. *Dr. E. A. Letts and James Davidson.*

2514. Hydrochlorate of the Hydrocarbon contained in Oil of Lavender (exotic); obtained by saturating oil of lavender with hydrochloric acid, and distilling with water vapour. No solid modification seems to exist.

Formula $C_{10} H_{16} 2 HCl$.

Dr. E. A. Letts and James Davidson.

2515. Sulphide of Potassium, obtained by allowing a very concentrated aqueous solution (prepared in the usual way) to remain at rest for some time. Sulphide of potassium is usually stated to be red and uncrystallizable from water.

Dr. E. A. Letts.

2516. Mono-sodium Glycerine, obtained by mixing glycerine with an alcoholic solution of ethylate of sodium. It contains a molecule of alcohol (acting as water of crystallization), which it loses at 100° C.

(*See* Berichte der deutschen chemischen Gesellschaft, 1872.)

Formula $C_3 H_5 (OH)_2 (ONa) + C_2H_6O$.

Dr. E. A. Letts.

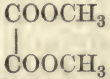
2517. Crystallized Pyro-sulphuric Acid, obtained by adding the equivalent quantity of sulphuric anhydride to oil of vitriol.

Formula $H_2 S_2 O_7$

Dr. E. A. Letts.

2518. Pure Oxalate of Methyl, used for the preparation of pure methyl alcohol.

Formula



$$\begin{array}{c} COOCH_3 \\ | \\ COOCH_3 \end{array}$$

Dr. E. A. Letts and R. M. Morrison.

2519. Pure Methyl Alcohol, obtained by the action of boiling water on the oxalate of methyl, and subsequent dehydration with lime and sodium.

Formula $H—CH_2 OH$

Dr. E. A. Letts and R. M. Morrison.

COLLECTION OF PREPARATIONS RESULTING FROM TECHNICAL AND SCIENTIFIC RESEARCH. CONTRIBUTED BY MEMBERS OF THE GERMAN CHEMICAL SOCIETY. (The names of the members are given below their contributions).

2677.

1. Anthracene.
2. Anthraquinone.
3. Dinitrobenzene.
4. Eosine potassium.
5. Methyl Violet.
6. Rubin (Rosanilinchlorhydrate).
7. Benzylchloride.
8. Aniline.
9. Hydrochlorate of Safranine.
10. Hofmann's Violet (Iodine Violet).
11. Toluene.
12. Coralline (Ammonium-rosolate).
13. Nitrobenzene.

14. Aurine (Rosolic acid).
15. Phenylene Brown.
16. Azobenzol.
17. Phosphine (Nitrate of Chrysaniline).
18. Nitronaphthaline.
19. Picric acid.
20. Diphenylamine.
21. Rosanilinbase.
22. Methyl Green, crystallized.
23. Nitrotoluene, solid.
24. Phtalic acid.
25. Toluidine, liquid.
26. Aniline Blue, soluble (Sodium-triphenylrosaniline-sulfate).
27. Toluidine, crystallized.
28. Phenol, crystallized.
29. Dimethylaniline.
30. Aniline Blue (Triphenylrosaniline-chlorhydrate).
31. Martius Yellow (Dinitronaphthol-calcium).
32. Dinitrocresol potassium.
33. Benzene, crystallized.
34. Naphtol.
35. Naphtylamine.
36. Methyldiphenylamine.
37. Naphtalene.
38. Aurantia.
39. Nigrosin, soluble in spirits.
40. Nigrosin, soluble in water.
41. Magdala-Red.
42. Mauve.
43. Cresol.

The compounds are intended for illustrating the present state of the coal-tar colour manufacture, and the above collection embraces all the preparations of this class manufactured at present.

Actien-Gesellschaft für Anilinfabrikation, Rummelsburg, near Berlin.

Monochlorcresol $C^6H^3\left\{\begin{array}{l}CH^3\\Cl\\OH\end{array}\right.$ (Fusing point 56°.)
Mesitol $C^6H^2(CH^3)^3OH$. (Fus. p. 68°—69°.)
Nitronaphtol-Potassium $C^{10}H^6(NO^2)OK$.
Nitronaphtol-Sodium $C^{10}H^6(NO^2)ONa + 2H^2O$.
Nitronaphtol-Barium $[C^{10}H^6(NO^2)O]^2Ba + H^2O$.
Nitronaphtol-Lead $[C^{10}H^6(NO^2)O]^2Pb$.
Bibromnaphtol $C^{10}H^5Br^2(OH)$. (F. p. 111°.)
Mononitrophenylendiamine $C^6H^3(NO^2)(NH^2)^2$.

Dr. Rud. Biedermann, Berlin.

Magnesium-platino-cyanide $Mg\,Pt\,(CN)_4$
Magnesium carbonate (crystallised).
Benzomonochloride $C_6H_5CH_2Cl$.
Benzodichloride $C_6H_5CHCl_2$.
Benzotrichloride $C_6H_5CCl_3$.
Monochlortoluene $C_6H_4ClCH_3$.
Monochlorbenzylchloride $C_6H_4ClCH_2Cl$.
Benzylsulphhydrate $C_6H_5CH_2SH$.
Benzylsulphide $(C_6H_5CH_2)_2S$.
Mercury-Benzylsulphide $(C_6H_5CH_2S)_2Hg$.
Benzylsulphoxyde $(C_6H_5CH_2)_2SO$.
Benzylsulphoxyde and very remarkable from their different power of crystallization.
Disulphobenzyle $(C_6H_5CH_2)_2S_2$.
Benzylxylene $C_{15}H_{16}$.
Benzylxylolketone $C_6H_5COC_6H_3(CH_3)_2$.
Benzoylisophtalic acid $C_6H_5COC_6H_3(COOH)_2$.
Benzoylisophtalate of barium $C_6H_5COC_6H_3BaC_2O_4$.
Benzoylisophtalate of Ethyl
Benzoylisophtalate of Methyl
$C_6H_5COC_6H_3\left\{\begin{array}{l}COOC_2H_5.\\COOC_2H_5.\end{array}\right.$
Isomeric anhydride of benzoylisophtalic acid $C_{15}H_{10}O_4$.
Benzylisophtalic acid $C_6H_5CH_2C_6H_3(COOH)_2$.
Benzylisophtalate of Barium, Calcium.
Barium-Ethylsulphate, $Ba\left\{\begin{array}{l}C_2H_5SO_4.\\C_2H_5SO_4.\end{array}\right.$
(Crystals of rare beauty.)

Anthracene.
Red Chromate of lead.
Green Chromate of lead.
Yellow Chromate of lead (chemically pure).
Turkish red.

The lead preparations are manufactured by means of chemically pure Ceruse.

Dr. Alex. Aug. Blatzbecker, Cologne.

Elaidic Acid. Fus. p. 45. Obtained from the oleine of stearin, manufactured by pressing it once in cold and once in heat.

Franz Bornemann, Verden.

Angelic acid; well shaped crystals, 1·2 cm. long, 3 mm. thick $C_5H_8O_2$.
Sodium-Ethylhyposulphite $SO_2\left\{\begin{matrix}C_2H_5\\ ONa\end{matrix}\right.$
Taurine Crystals, 5 cm. long $C_2H_7NSO_3$.
Cubebene-Stearoptene $C_{15}H_{26}O$.
Hydrochlorate of Cubebene $C_{15}H_{24}HCl$.
Hydrochlorate of Turpentine $C_{10}H_{16}HCl$.
Terpin $C_{10}H_{20}O + H_2O$.
Chelidonic acid $C_7H_4O_6 + H_2O$.
Bromalhydrate crystals, long 4 cm., high 2 cm., thick 1 cm. $C_2HCl_3OH_2O$.
Arbutine $C_{25}H_{34}O_{14}$.
Iodine cyanide CNI.
Barium-Amylsulphate $(SO_4C_5H_{11})_2Ba$.
Potassium-dichloracetate $C_2HCl_2KO_2$.
Potassium-Stannocyanide $Sn\,(CN)_22KCN$
Ethyl-dichloracetate $C_2HCl_2C_2H_5O_2$.
Octyl-Butyrate, Ethereal oil of Pastia.
Octyl-Butyrate, Ethereal oil of Hera cleum Spondyl.
Octylalcohol norm. $C_8H_{18}O$.
Octylacetate norm. $C_8H_{17}OC_2H_3O$.
Iodine-trichloride-potassium-chloride $KClICl_3$.

Breslau, Pharmaceutical Institute of the University; Prof. Dr. Poleck.

Tetramethylammoniumtriiodide $(CH_3)_4NI_3$.
Tetramethylammoniumpentaiodide $(CH_3)_4NI_5$.
Trimethylethylammoniumtriiodide $(CH_3)_3(C_2H_5)NI_5$.
Trimethylethylammoniumpentaiodide $(CH_3)_3(C_2H_5)NI_5$.
Methyltriethylammoniumtriiodide $(CH_3)(C_2H_5)_3N_5I_3$.
Tetrethylammoniumpentaiodide $(C_2H_5)_4NI_5$.
Tetraethylammoniumtribromide $(C_2H_5)_4NBr_3$.
Molybdenumdichloride Mo_2Cl_4.
Molybdenumdichloride $Mo_2Cl_43H_2O$.
Molybdenumtrichloride Mo_2Cl_6.
Molybdenumtetrachloride $MoCl_4$.
Molybdenumpentachloride Mo_2Cl_5.
Molybdenum-oxychloride MoO_2Cl_2.
Molybdenum-oxytetrachloride $MoOCl_4$.

The Polyiodides of the ammonium-bases are resulting from the researches of Weltzien.

The Molybdenum-chlorides and oxychlorides are prepared by Liechti and Kempe.

The large tube of Molybdenum-pentachloride has been prepared recently by Aronheim and Bornemann.

Carlsruhe, Chemical Laboratory of the Polytechnic Academy; Prof. L. Meyer.

Phosphenylchloride $C_6H_5PCl_2$.
Phosphenyltetrachloride $C_6H_5PCl_4$.
Phosphenylchlorobromide $C_6H_5PCl_2Br_2$.
Phosphenylchlorotetrabromide $C_6H_5PCl_2Br_4$.
Phosphenyloxychloride $C_6H_5PCl_2O$.
Phosphenylic acid $C_6H_5PO(OH)_2$.
Calcium-phosphenylate $C_6H_5PO(O_2Ca)$.
Phosphenylous acid $C_6H_5PO(OH)H$.
Trichlortolylphosphinic acid $C_6H_4CCl_3PO(OH)_2$.

Diethylphenylphosphine $C_6H_5(C_2H_5)_2P$.
Monophenylphosphoric chloride $POCl_2(OC_6H_5)$.
Diphenylphosphoric chloride $POCl(OC_6H_5)_2$.
Monophenylphosphoric acid $PO(OC_6H_5)(OH)_2$.
Phosphorchlorotetrabromide PCl_3Br_4.
Amidophosphenylic acid $C_6H_4(NH_2)PO(OH)_2$.
Nitrophosphenylic acid $C_6H_4(NO_2)PO(OH)_2$.

Carlsruhe, Chemical Laboratory of the Polytechnic Academy ; Prof. A. Michaelis.

1. Chlorbromacetic acid.
2. Chloral-cyanide-cyanate.
3. Chloral-anilide.

Dr. C. V. Cech, Berlin.

1. Triphenylbenzene
2. Triphenylbenzene } different crystallisations.
3. Triphenylbenzene
4. Sulphide of benzophenone.
5. Triphenylic ether.
6. Crystallized Pinakon of the Acetophenone.

Prof. Engler, Halle.

Benzoic acid sublimed from urine. Fine crystals with scarcely any smell; possessing a pure white colour.

Furtenbach and Oelhafen, Reichelsdorf near Nuremberg.

Ammonium bicarbonate $CO\left\{\begin{matrix}OH\\ONH^4\end{matrix}\right.$ This compound, hitherto found in the working apparatus of gas manufactories where the apparatus has the temperature of the surrounding air, is interesting on account of its having been observed in the gas-discharge pipes of hydraulic machines. The pipes have a temperature of 50° C. and upwards, at which temperature carbonate of ammonia for the most part dissociates into its components. No iodine was found in the compound; the dark colour was owing to coal-dust.

Oxalic acid from lighting gas, $C^2O^4H^2,2H^2O$, obtained by treating larger quantities of coal-gas with fuming nitric acid, after having withdrawn from the gas the vapours of hydrocarbons by means of intense cold.

Oils from lighting gas from Silesian coals obtained in very small quantity by exposure of large quantities of lighting gas to the intense cold of $-21°$ R.

Gaswerke Städtische, Berlin (Dr. Tieftrunk).

1. Stannous chloride, Tin salt, $SnCl^2 + 2H^2O$ chemically pure, contains 52 per cent. of Sn.

2. Stannic chloride, $SnCl_4 + 5H_2O$, contains 43 per cent. of Sn.

3. Sodium-stannate contains 42–44 per cent. of Stannic oxide in soluble form, $Na_2SnO_3 + 2H_2O$.

Th. Goldschmidt, Berlin.

Sample of the first Boron ever made, Bo.
" Aluminium, Al.
" Urea, $CO(NH_2)_2$.
Wolfram phosphide.
Silicon-calcium.
Amorphous Silicon, from Silicon-hydride.
Titaniumcyanochloride $TiCl_4CNCl$.
Chromic oxide Cr_2O_3.

Cyanotitaniumnitride Ti_5CN_4.
Crystal of Arsenous anhydride As_2O_3.
Silicon-Nitride.
Phosphoruscyanide $P(CN)_3$.
* Bariumorthonitrobenzoate $(C_6H_4(NO_2)(NO_2)^oCOO)_2Ba + 3H_2O$.
* Ethylorthonitrobenzoate $C_6H_4(NO_2)oCOOC_2H_5$.
Sodiummetanitrobenzoate $C_6H_4(NO_2)^mCOONa + 3H_2O$.
* Ethylmetanitrobenzoate $C_6H_4(NO_2)^mCOOC_2H_5$.
* Bariummetanitrobenzoate $(C_6H_4(NO_2)^mCOO)_2Ba + 4H_2O$.
* Bariumparanitrobenzoate $(C_6H_4NO_2)^pCOO)_2Ba + 5H_2O$.
*Ethylparanitrobenzoate $C_6H_4(NO_2)^pCOOC_2H_5$.
Sodiumsulphbenzoate $C_6H_4COOHSO_2ONa$.
Orthonitrobenzanilide from Benzanilide $C_6H_4\left\{\begin{matrix}NO_2^o\\ NH\end{matrix}\right.(COC_6H_5)$.
Metanitrobenzanilide, from Benzanilide $C_6H_4\left\{\begin{matrix}NO_2^m\\ NH\end{matrix}\right.(COC_6H_5)$.
Paranitrobenzanilide, from Benzanilide $C_6H_4\left\{\begin{matrix}NO_2^p\\ NH\end{matrix}\right.(COC_6H_5)$.
Parabromtoluene $C_6H_4CH_3Br^p$.

Those bodies marked with * are prepared for the crystallographic investigation of isomeric compounds.

Göttingen; Universitäts Laboratorium (Prof. Wöhler and Prof. Hübner).

1. Triacetonamine.
2. Triacetonamine nitrate.
3. Triacetonamine sulfate.
4. Triacetonamine oxalate.
5. Triacetonamine bioxalate.
6. Chlorhydrate of Triacetonammonium-platinochloride.
7. Chlorhydrate of Triacetonammonium-platinchloride.
8. Diacetonamine nitrate.
9. Diacetonamine binoxalate.
10. Chlorhydrate of Tri-isotriacetonammoniumplatinochloride.
11. Diacetonammoniumplatinochloride.
12. Diacetonic alcohol.

Prof. Dr. W. Heintz, Halle a. S.

Metallic modification of phosphorus; the crystalline leaves are on lead and isolated from the lead by means of diluted nitric acid.

Prof. W. Hittorf, Münster, Westfalia.

1. Dimethylammoniumchloride.
2. Trimethylammoniumchloride.
3. Tetramethylammoniumiodide.
4. Diethylamine.
5. Triethylamine.
6. Tetraethylammoniumiodide.
7. Ethylendiaminchlorhydrate.
8. Monophenyloxamide.
9. Phenylated diacetamide.
10. Formamide.
11. Phosphoniumiodide.
12. Ethylphosphiniodide.
13. Dibenzylphosphine.
14. Ethenyldiphenyldiamine.
15. Melaniline.
16. Melanilinnitrate.
17. Melanilinsulphate.
18. Diphenylparabanic acid.
19. Ethylic sulfocyanate (Ethylmustardoil).
20. Methylic sulfocyanate (Methylmustard oil).
21. Phenylic sulfocyanate (Phenylmustardoil).
22. Allylacetate.
23. Allylalcohol.
24. Allylamine.
25. Allylsulphide.
26. Carbanilide.
27. Sulphocarbanilide.

28. Cyananiline.
29. Monobromaniline.
30. Toluylendiamine.
31. Dinitrobenzene.
32. Base from the residues of the Aniline manufacture, $C_{19}H_{26}N_2$.
33. Toluidinehydroxalate.
34. Toluidinechlorhydrate.
35. Toluidinesulphate.
36. Melanilinehydroxalate.
37. Toluylic acid from Lepidium sativum.
38. Nitrophenol.
39. Rosanilinchlorhydrate.
40. Iodine-combination of Methyl-green.
41. Potassium salt of Eosine.
42. Xylidine pure.
43. Tetraphenylmelamine.

Prof. A. W. Hofmann, Berlin.

Collection of Substances discovered or investigated by Liebig.

Bariumperoxyd.
Phosphorus nitride.
Nitrogen chlorophosphide.
Acetal.
Acetone.
Aldehydeammonia.
Metaldehyde.
Formic acid.
Asparagin.
Asparic acid.
Aethylenechloride.
Butyric acid.
Calciumchloride, Acetic ether.
Carbothialdine.
Comenic acid.
Chloral.
Chloralhydrate.
Citraconic acid.
Acetate of Ethyle.
Lactose.
Sodium ethylate.
Barium methionate.
Manganeseoxalate.
Oxalate of Ethyle.
Ferrous oxalate.
Oxamate of Ethyle.
Oxamide.
Mercaptide of mercury.
Cane sugar.
Stearic acid.
Mucic acid.
Thialdine.
Vinylphosphate of barium.
Vinylsulphate of barium.
Vinylsulphate of calcium.
Tartaric acid.
Potassium-cyanate.
Cyanuric acid.
Fulminate of ammonium.
Fulminate of barium.
Persulphocyanic acid.
Sulphocyanate of silver.
Sulphocyanate of potassium.
Sulphocyanate of ammonium.
Urea.
Mercuric oxyde-urea.
Uric acid.
Alloxane.
Alloxanate of barium.
Alloxantine.
Allantoine.
Ammeline-nitrate.
Ammelide.
Dialurate of ammonium.
Melam.
Melamine.
Mellonate of potassium.
Mesoxalate of barium.
Murexide, pure.
„ commercial.
Oxalurate of ammonium.
Parabanic acid.
Uramil.
Kreatine.
Sarkosinechlorhydrate.
Thionurate of ammonium.
Xanthogenate of potassium.
Benzoic aldehyde.
Benzoylchloride.
Benzoylbromide.
Benzoylcyanide.
Benzoyliodide.
Benzil.
Benzilic acid.
Benzoin.
Benzoate of Ethyle.
Mandelic acid.
Picric acid.
Atropine.
Brucine.
Caffeine.
Cinchonine.
Morphine.
Meconic acid.

Narcotine.
Nicotine.
Strychnine.
Opianic acid.
Piperine.
Metagallic acid.
Mycomelic acid.
Valeric acid.
Fulminate of potassium.

Prof. A. W. Hofmann, Berlin

Calcined soda, 98 per cent. Na^2CO^3.
Calcined soda, 100 per cent. Na^2CO^3.
Sodium bicarbonate, $HNaCO^3$.

The preparations have been obtained by the exhibitor by an ammonia-soda process carried out and developed by himself. This method has been introduced in the exhibitor's factory at Grevenberg, near Aix-la-Chapelle; at the Nuremberg Soda Manufactory, near Nuremberg; at the Soda Manufactory of the Rothenfeld Saline and Salt Bath Company at Rothenfelde, near Osnabrück, and at the Aalborger chemiske Fabrikker og Gjödningsfabrik at Aalborg in Denmark. *Moritz Honigmann, Aachen.*

Dextrin.
Monobasic sugar-lime.
Tribasic „
Double phosphate of manganese and ammonium.
Artificial wax.
Paraffin.

Dr. Franz Hulwa, Breslau.

Barium-platino cyanide, $Pt(CN)_2Ba(CN)_24H_2O$.
Barium-chlorate, $BaCl_2O6$.
Cuprous oxide, Cu_2O.
Stannous oxide, SnO. *J. Hutstein, Manufacturer, Breslau.*

1. Quinine puriss crystall.
2. Cotoin, the crystalline principle of the Coto bark.
3. Coto Bark.
4. Quinine salicylic. cryst.
5. Quinine phenylo-muriat.
6. Quinine phenylosulfuric.
7. Sulphophenylate of Cinchonidine.
8. Echicerin.
9. Echitin.
10. Echitëin, crystalline principle of the Dita bark.
11. Dita bark.
12. Santoninic Acid.
13. Quinamine.
14. Laudamine.

The salts of Quinine exhibited were at first prepared in the Stuttgart manufactory, and the above-mentioned new preparations—Cotoin, Echicerin, Echitëin—have been made out by the investigations of MM. Jobst and Hesse, Stuttgart.

Fried. Jobst, Stuttgart.

1. Methylic alcohol pure.
2. Formic acid cryst.
3. Methylsulphocarbylamin, $CH_3-N=CS$.
4. Sulphocarbamid.
5. Guanidine, CH_5N_3.
6. Iodoform.
7. Nitroethane, $C_2H_5-N=O_2$.
8. Ethylsulphocarbylamin, $C_2H_5-N=CS$.
9. Acetaldehyde.
10. Paraldehyde.
11. Aldehyde.
12. Isopropylic alcohol.
13. Isobutylic alcohol.
14. Allylic alcohol.
15. Propionic acid.
16. Allylamine.
17. Methylethylketon, $CH_3-CO-C_2H_5$.
18. Isobutylic alcohol.
19. Trimethylcarbinol.
20. Monochlorcrotonic acid.
21. Amylic ether.
22. Furfurol.
23. Capronitrile.
24. Capronic acid from the nitrile.
25. Hexyliodide from mannite.
26. Orcine.
27. Pyrocatechin.
28. Resorcin.
29. Hydroquinone.
30. Quinone.

C. A. F. Kahlbaum, Berlin.

Acidum Benzoicum ex urina, $\left.\begin{matrix}C_7H_5O,\\ H\end{matrix}\right\}O.$

Kaufmann's manufactory of Benzoic acid is the largest on the Continent.

Karl Joseph Kaufmann, Königsberg, in Prussia.

Sinistrin.
Albumin, soluble from barley.
Albumin, coagulated from barley.
Oil fatty, from barley.
Sugar from barley in form of syrup.
Sugar from barley crystallised.
Cerealic acid.

Dr. G. Kühnemann, Dresden (later Görlitz).

1. Didymiumsulfate.
2. Iridium-sodium-sesquichloride.
3. Rhodium-sodium-sesquichloride.

Used for measuring the crystals.

Prof. von Lasaulx, Breslau.

One specimen of bromine.
One specimen of bitter salt.
Two specimens of magnesiumchloride.
One specimen of potassiumchloride, 98 per cent.
One specimen of potassiumchloride, 80 per cent.

Leopoldshaller Vereinigte chemische Fabriken, Actien-Gesellschaft, Leopoldshall near Stassfurt.

1. Cörulignone $C_{16}H_{16}O_6$.
2. Hydrocorulignone $C_{16}H_{18}O_6$. White in small crystals.
3. Hydrocorulignone $C_{16}H_{18}O_6$. Brownish in large crystals.
4. Bibromanthracenetetrabromide $C_{14}H_8Br_6$.
5. Bibromanthracene $C_{14}H_8Br_2$.
6. Tetrabromanthracene $C_{14}H_6Br_4$.
7. Anthraquinone $C_{14}H_8O_2$.
8. Anthracene $C_{14}H_{10}$. Blue fluorescence.
9. Chrysene (yellowish) $C_{18}H_{12}$.
10. Chrysene (white) $C_{18}H_{12}$.
11. Chrysoquinone $C_{18}H_{10}O_2$.
12. Xylindein
13. Monooxyanthraquinone $C_{14}H_7(OH)O_2$.
14. Dichloranthracene $C_{14}H_8Cl_2$.
15. Binitroanthraquinone $C_{14}H_6(NO_2)_2O_2$.
16. Biamidoanthraquinone Sublimed. $C_{14}H_6(NH_2)_2O_2$.
17. Hydrochrysamide $C_{14}H_2(NH_2)_4(OH)_2O_2$.

Prof. C. Liebermann, Berlin.

1. *Hyoscyamine crystals.*—Crystallised alkaloid from Hyoscyamus niger and alb., produced for the first time in larger quantities and brought into the market; crystallised in snow-white needles. According to the investigations of Dr. Harnack at Strassburg, and Dr. Fronmüller in Fürth (which, however, have not yet been brought to a conclusion), this preparation is exceedingly effective, and is in this respect almost equal to atropine.

The smallest dose which paralyses the termination of the vagus of the heart of a frog, consists of 1/200 milligramme (0·000005). (Raising of the suspended beating of the heart by Muscarin) the dose which still produces genlarement of the pupil of a rabbit, is 1/250 milligramme (0·000004) [Harnack].)

2. *Amorphous Hyoscyamine.*—Amorphous alkaloid from Hyoscyamus niger and alb. The smallest dose which paralyses the terminations of the vagus of the heart of a frog is in this instance 1/100 milligramme (0·000001, Harnack).

3. *Ditaine crystal.*—Crystallised bodies from the cortex dita of Echites scholaris, only recently introduced into medicine.

4. *Ditamine.*—Amorphous alkaloid from the same bark. Both bodies quite new in trade. They represent the effective substances of this drug.

5. *Kamalin crystal.*—Crystallised body from Kamala, the fibres and glands of the fruit of Rottlera tinctoria. Effective substance of this drug. New in trade.

6. *Muscarin nitricum.*—Nitrate of the alkaloid contained in the toadstool (Agaricus muscarinus). Muscarin is likewise new in commerce.

7. *Pilocarpin.*—Alkaloid from the leaves of Policarpus pinnatifolius, *Saborandi*, since a short time only employed in medicine. New in commerce.

8. *Veratric acid*, from the seeds of Sabadilla.

9. *Kosin crystallisatum.*—The acting principle of the Koso plant crystallises partly in needles, partly in short thick prisms belonging to the rhombic system. Almost insoluble in water, it is easily dissolved in ether, benzol, sulphide of carbon, and chloroform. Less easily in glacial acetic acid and alcohol.

For further particulars *see* Schroff, "Ausstellungsbericht" (Vienna), page 32; Flückiger, "Archiv der Pharmacie," 1874, part 2, and "Pharmaceutical Journal, transactions, 1875, No. 238."

10. *Apomorphia hydrochlor. crystal.*—Pure and certain acting preparation, *see* Harnack, "Archiv für experimentale Pathologie und Pharmakologie." Dr. Juratz, "Zeitschrift für Medizin."

Emanuel Merck, Darmstadt.

1. Telluric acid $H_2TO4 + 4H_2O$.
2. Tellurous anhydride TO_2.
3. Iodbromide of mercury HgIBr.
4. The same, larger crystals.
5. Phosphide of cadmium.
6. Methyl-benz-acetol $CH_3 - C(C_7H_5O)_2 - CH_3$. Prepared from monochlorpropyleniodhydrate by means of silverbenzoate.
7. Menthol $C_{10}H_{19}OH$.
8. Menthyl-acetate $C_{10}H_{19}OC_2H_3O$.
9. Menthene $C_{10}H_{18}$.
10. Borneol $C_{10}H_{17}OH$ (natural).
11. Benzoic aldehyde C_7H_6O. Prepared synthetically from $C_6H_5CHCl_2$ by means of sulphuric acid.
12. Phthalic anhydride $C_8H_4O_3$. Large crystals formed by slow decomposition of the chloride in moist air.
13. Ethyl aceto-acetate $CH_3COCH_2COOC_2H_5$ Prepared synthetically from acetic ether.
14. Dehydracetic acid $C_8H_8O_4$.
15. Oxyuvitic acid $C_9H_8O_5$. Prepared synthetically from acetic ether.
16. Metacresol C_7H_7OH. Prepared synthetically from acetic ether.
17. Metacresol-ethylic ether $C_7H_7OC_2H_5$. Prepared synthetically from acetic ether.
18. Oxybenzoic acid $C_6H_5OHCOOH$. Prepared synthetically from acetic ether.
19. Methyl-oxybenzoic acid $C_6H_5OCH_3COOH$.
20. Methyloxybenzoate of calcium $(C_6H_5OCH_3COO)_2Ca + 4H_2O$.
21. Hydro-oxybenzoic acid $C_6H_6OHCOOH$.
22. Cresotic acid $C_7H_6OHCOOH$.
23. Trinitrocresol $C_7H_4(NO_2)_3OH$.

Prof. A. Oppenheim, Berlin.

Butylchloral $C_4H_5Cl_3O$.
Butylchloral-hydrate $C_4H_7Cl_3O_2$.
Trichlorbutyric acid $C_4H_5Cl_3O_2$.
Chlorangelactic acid $C_5H_7ClO_3$.
Chloralcyan-hydrate $C_3H_2Cl_3NO$.
Trichlorolactate of ethyl $C_5H_7Cl_3O_3$.
Chloracrylate of ethyl $C_5H_7ClO_2$.
Bromalcyanhydrate $C_3H_2Br_3NO$.

Dr. A. Pinner, Berlin.

Chloralhydrate, large crystals
Chloralhydrate, small crystals
Chloralhydrate, in powder
Chloralhydrate, in crusts } $C_2HCl_3O + H_2O$.
Chloroform from Chloral, $CHCl_3$.

All these preparations are perfectly pure, the chloralhydrate being a special product of the manufactory.

Saame and Co., Ludwigshafen on the Rhine.

Phenol, pure, is perfectly free from cresol, and therefore *perfectly* soluble in 20 times its quantity of water.

Phosphoric acid, chemically pure; the commercial so-called fused phosphoric acid contains up to 25°/₀ sodium-pyrophosphate.

Salicylic acid cryst., perfectly soluble in water, alcohol, and ether.

Salicylic acid subl.

Tannin leviss. contains only a very trifling quantity of glucose, is therefore, according to H. Schiff, nearly pure digallic acid.

Monobromcamphor.

Trichloride of carbon.

Salicylate of quinine.

Chloralhydrate in plates.

Chloralhydrate in crystals, prepared according to the special directions of O. Liebreich, perfectly free of other chlorinated compounds, and is unchangeable for years.

Chloralide.

Butylchloral.

Saccharate of iron, soluble, not containing any free sugar, but a pure chemical compound of ferric oxyde, soda, and sugar.

Bromide of potassium, entirely unaffected by barium salts.

Iodide of potassium, like the above, and free from iodic acid, therefore entirely unchangeable.

Potassium hydrate.

Permanganate of potassium.

Salicylate of sodium, easily soluble in water and alcohol.

Salicylate of zinc.

E. Schering, Berlin.

Hyposulphate of sodium $Na_2S_2O_6 + 2H_2O$.
Hyposulphate of barium $BaS_2O_6 + 4H_2O$.
Hyposulphate of strontium $SrS_2O_6 + H_2O$.
Hyposulphate of lead $PbS_2O_6 + 4H_2O$.
Selenium, precipitated.
Cube of selenium.
Tellurium in rods Te.
Tellurium in cubes.
Telluric acid H_2TeO_4.
Iodide of carbon CI_4.
Silicon-sulphide SiS_2.
Chlorate of sodium, three different crystalline forms, $NaClO_3$.
Periodate of sodium $NaIO_4 + 3H_2O$.
Arseniate of sodium $HNa_2AsO_4 + 12H_2O$.
Lithium in wire, Li.
Lithium in balls, Li.
Lithium in bars.
Beryllium metal Be.
Berylliumchloride, sublim, $BeCl_2$.
Sulphate of Beryllium $BeSO_4 + 2H_2O$.
Nitroprusside of sodium $Cy_3Fe_2NO_2, 2CyNa + 2H_2O$.
Zirconium metallic, Zr.
Calcium met., obtained by electrolysis, Ca.
Strontium met., obtained by electrolysis, Sn.
Yttriumplatinocyanide $YCy_4Pt + 7H_2O$.
Didymiumplatinocyanide $Di_2Cy_{12}Pt_3 18H_2O$.
Sulphate of Ceroso-ceric oxide $Ce_5S_6O_2 + 21H_2O$.
Nitrate of Cerium-magnesia $MgN_2O_6 + CeN_2O_6 + 8H_2O$.
Nitrate of Cerium-nickel $NiN_2O_6 + CeN_2O_6 + 8H_2O$.
Nitrate of cerium and didymium $DiN_2O_6 + 4H_2O$.
Oxalate of yttrium $YC_2O_4 + 4H_2O$.
Oxalate of erbium $ErC_2O_4 + 3H_2O$.
Oxalate of cerium CeC_2O_4.
Oxalate of didymium $DiC_2O_4 + 4H_2O$.
Oxalate of thorium $ThC_4O_8 + 2H_2O$.
Sulphate of thorium $ThS_2O_8 + 9H_2O$.
Manganese metal Mn.
Nickelbromide subl. $NiBr_2$.
Sulphate of nickel $NiSO_4 + 7H_2O$.
Sulphate of nickel and potash $NiSO_4 + K_2SO_4 + 6H_2O$.

Selenate of copper $CuSeO_4 + 5H_2O$.

Sulphate of copper-oxyde-ammonia $CuSO_4 + 4NH_3 + H_2O$.

Arsenious acid crystallised from hot hydrochloric acid.

Iodide of arsenic, subl. As_2I_3.

Iodide of antimony, subl. SbI_3.

Fused vanadic acid V_2O_5.

Acid vanadate of sodium $Na_2V_4O_{11} + 9H_2O$.

Acid vanadate of ammonium $(NH_4)2V_4O_{11} + 4H_2O$.

Molybdic acid, subl. MoO_3.

Titaniumsesquichloride Ti_2Cl_6.

Acetate of calcium and copper $\left.\begin{matrix}(C_2H_3O_2)_2Ca\\(C_2H_3O_2)_2Cu\end{matrix}\right\} 5H_2O$

Sulphocarbonate of potassium $CS<\begin{matrix}SK\\SK\end{matrix}$

Sulphocarbonate of sodium $CS<\begin{matrix}SNa\\SNa\end{matrix}$

Xanthogenate of sodium $CS<\begin{matrix}OC_2H_5\\SNa\end{matrix}$

Xanthogenate of potassium $CS<\begin{matrix}OC_2H_5\\SK\end{matrix}$

Hippuric acid $CH_2\left\{\begin{matrix}NHC_7H_5O\\CO_2H\end{matrix}\right.$

Carbonate of guanidine $CH_5N_3H_2CO_3$.

Levulinate of calcium $(C_5H_7O_3)2Ca + 2H_2O$.

Nitrate of cytisine.

Lithofellinic acid $C_{20}H_{36}O_4$.

Phthalic anhydride $C_6H_4\left\{\begin{matrix}CO\\CO\end{matrix}\right.O$.

Stilbene, pure $\left\{\begin{matrix}CH-C_6H_5.\\CH-C_6H_5.\end{matrix}\right.$

Stilbene, common $\left\{\begin{matrix}CH-C_6H_5.\\CH-C_6H_5.\end{matrix}\right.$

Triphenylbenzene $C_6H_3(C_6H_5)_3$.

Styracene.

Nitrosodimethylaniline $C_6H_4(NO)N(CH_3)_2$.

Nitrosodimethylaniline aniline $[C_6H_4(NO)N(CH_3)_2]_2 + C_6H_5NH_2$.

Phenanthrene $C_{14}H_{10}$.

Acetophenon C_6H_5, CO, CH_3

Benzophenon C_6H_5, CO, C_6H_5.

Cases containing 64 preparations of the metals and other elements.

Dr. Theodor Schuchardt, Görlitz, Silesia.

Coniferin $C_{16}H_{22}O_8 + 2H_2O$.

Vanillin $C_8H_8O_3$, small crystals are in this shape, the commercial product.

Vanillin $C_8H_8O_3$, slowly crystallised from dilute solutions.

Vanillin $C_8H_8O_3$, from residues of the artificial preparation of vanillin, and sublimed in the same manner as the vanillin of the Vannilla pods at the ordinary temperature.

Vanillic acid, slowly crystallised from dilute solution.

Vanillic acid $C_8H_8O_4$, finely crystallised as commercial commodity.

Sugar-vannillic acid $C_{14}H_{18}O_9$, prepared by Reimer and Tiemann. The compound is crystallised in the bottle itself.

Acetoeugenol $C_{12}H_{14}O_3$, prepared by Nagai and Tiemann.

Ferulic acid $C_{10}H_{10}O_4$, prepared by Nagai and Tiemann. The above acid is prepared synthetically from Vanilla; the white opaque crystals are re-crystallised from alcohol, the yellowish brilliant from water.

Dr. F. Tiemann and Dr. W. Haarmann, Berlin and Holzninden.

$$\text{Allylic-Alcohol}\left\{\begin{matrix}CH^2.\\CH.\\CH^2OH.\end{matrix}\right.$$

Prepared by distilling glycerine with oxalic acid and traces of sal ammoniac.

Prof. B. Tollens, Göttingen.

Chromic acid.

Molybdic acid, fused and sublimed specimens.

Molybdic acid, fused.

Molybdic acid, sublimed.

Selenious acid.

Tellurous acid.

Tungstic acid.

Vanadic acid.
Aluminiumsulphate.
Bariumbromide.
Bariumperoxyde cristall.
Berylliumsulphate.
Cadmiumbromide.
Cadmiumsulphide.
Caesium-alum.
Calciumchloride fus.
Ceriumprotosulphate.
Ceriumpersulphate.
Chromiumsulphate.
Cobalt sulphate.
Ammonium copper tartrate.
Potassium copper chromate.
Copper oxyde.
Ferric chloride, subl.
Didymsulphate.
Sulphide of iron.
Lanthansulphate.
Lead-dithionate.
Leadnitrite.
Lithiumcitrate.
Lithiumsulphate.
Metallic manganese.
Manganese chloride.
Metallic molybdenum.
Ammonmolybdate.
Nickelsulphate.
Potassiumhydrate in rods.
Potassiumhydrate in cakes.
Potassiumhydrate, pure.
Potassiumnitrite.
Rubidium alum.
Sodiumbromate.
Sodiumhydrate.
Sodiumhydrate, pure.
Sodiumdithionate.
Sodiumphosphotungstate.
Phosphotungstic acid.
Sodiumsilicate, crist.
Strontiumhydrate.
Tellurium.
Thalliumcarbonate.
Thalliumsulphate.
Thoriumsulphate.
Potassium titanfluoride.
Metallic Tungsten.
Ammoniumtungstate.
Ammonium Uranocarbonate.
Uraniumnitrate.
Yttr. Erb. oxid.
Yttr. Erb. sulfate.
Zincchloride fus.
Zircon. Potass. fluorid.
Ammoniummellilate.
Paramide.
Copper cyanide violet.
Copper cyanide green cryst.
Mercury-cyanide.
Barium platinocyanide.
Magnesium platinocyanide.
Potassium platinocyanide.
Potassiumcyanate.
Sulphocyanammonium.
Nitroprusside of sodium.
Cyanuric acid.
Ureanitrate.
Alloxan.
Ammonthionurate.
Carbontetrachloride.
Iodoform.
Potassium sulphomethylate.
Oxalate of methyle.
Copperformiate.
Strontiumformiate.
Butyric ether.
Capronic ether.
Ethyloxalate.
Sebacic ether.
Ethylenechloride.
Ethylenebromide.
Bariumsulphethylate.
Carbonhexachloride.
Glycol.
Aldehydeammonia.
Monochloracetic acid.
Acetamide.
Ammonium acetate.
Propylic alcohol norm.
Propylacetate.
Propionic acid from propylic alcohol.
Aceton. Natr. bisulfit.
Dichlorhydrin.
Lactic acid.
Zinc lactate.
Isobutylic alcohol.
Butyric acid from fermentation.
Amylchloride.
Bariumsulphamylate.
Valeral-sodium-bisulphite.
Capronic acid from fermentation.
Capronic acid from valerianic acid—residues.
Caprylic acid.
Caprinic acid.
Bariumcapronate.
Caprylic alcohol.
Methyloenanthol.
Capronic acid from caprylic alcohol.
Ethal.

Sebacic acid.
Malic acid.
Calciumbimalate.
Aconitic acid.
Anisic acid.
Asparaginic acid.
Camphoric acid.
Cinnamic acid.
Cuminic acid.
Fumaric acid.
Picramic acid.
Salicylous acid.
Sorbic acid.
Camphormonobromide.
Benzolbichloride.
Benzoin.
Styracin.
Styrol.
Benzoylalcohol from crude cinnamic alcohol.
Phenylpropylic alcohol.
Monochlortoluene.
Xylene.
Naphtalinbichloride.
Mesitylene.
Cymene.
Chrysophanic acid.
Emodine.
Aporetin.
Erythroretin.
Phaoretin.
Gentisine.
Haematoxyline.
Indigotin.
Taurin.
Glycyrrhizin.
Melampyrite (Dulcit).
Glycocoll.
Inosite.
Allantoin.
Taurin.
Hyoglycocholic acid.
Aconitine.
Aesculin.
Amygdalin.
Anemonin.
Anemonic acid.
Arbutin.
Methylhydroquinone from Arbutine
Green Hydroquinone from Arbutine
Asaron.
Atropine.
Tropinsulphate.
Atropa acid.
Tropa acid.
Berberinnitrate.
Cantharidin.
Caffeine, raw.
Caffeine, pure crist.
Colchicin.
Columbin.
Conine.
Corydalin.
Coumarin.
Cubebin.
Daturine.
Delphinine.
Elaterine cryst.
Filicin.
Filimelissic acid.
Ononine.
Helenin.
Lactucerin.
Imperatorin.
Peucedanin.
Picrotoxin.
Piperine.
Potassiumpiperinate.
Quercitrin.
Quininvalerate.
Saponin.
Solanin.
Stramonine.
Syringin.
Theobromine.
Urson.
Veratrine.
Rubidiumbitartrate.

Dr. H. Trommsdorff, Erfurt.

Stafsfurt "Abraumsalz."
Potassium chloride, obtained by means of hot extraction.
Kieserite, obtained by cold lixiviation of the residues of the above process.
Picromerite, obtained by action of Kieserite on Potassium chloride in the heat.
Potassium sulphate, prepared by decomposition of the picromerite by means of potassium chloride.
Potash (crude fused), by fusion of the potassium sulphate with lime and charcoal (Leblanc's Process).
Potash 95°/₀, by evaporation and calcination of the leys from the above.
Potash hydrated, free from sulphuric acid; by refinement of the potash at 95°/₀.

These specimens show the various stages in the preparation of potash from the mineral salts.

Vorster and Grüneberg, Kalk b. Cöln.

Phenoquinone $C_{18}H_{14}O_4$.
Pyrogalloquinone $C_{18}H_{14}O_8$.
Purpurogallin $C_{18}H_{14}O_9$.
Triacetamide $C_6H_9O_3N$.
Bicyannaphtalene $C_{12}H_6N_2$.
Bioxynaphtalene $C_{10}H_8O_2$.
Picric acid Bromonaphtalene $C_6H_2(NO_2)_3OHC_{10}H_7Br$.
Binitronaphtalene $C_{10}H_6N_2O_4$.

Prof. Wichelhaus, Berlin.

1. Bars of nickel; 2, bars of cobalt. These metal bars are about 170mm. long and 42mm. broad and brightly polished. They form the first cast pieces of cobalt and nickel of a large size which have ever been produced, and date from the year 1866. W. Hankel made use of the same in his investigations on the magnetic bearing of nickel and cobalt. (Berichte der Königl. Sächsischen Gesellschaft der Wissenschaften, mathematisch-physikalische Klasse. Meeting of the 21st July 1875.)

Prof. Winkler, Freiberg, Saxony.

2536a. Chemical Preparations (**61**) from the works of Engelhardt, Latschinow, Wolkow, Maïkupar. Produced in the Laboratory of the Agricultural Institute of St. Petersburg.

Chemical Society of Russia, University of St. Petersburg.

COLLECTION OF RUSSIAN CHEMICALS.

1. α Naphtol.
2. β Naphtol.
3. α Naphtylsulphuric chloride.
4. β Naphtylsulphuric chloride.
5. α Benzoylnaphtol.
6. β Benzoylnaphtol.

Maikopar.

7. Mononitrochlorbenzol.
8. Binitrochlorbenzol.
9. β Cresotinic acid.
10. γ Cresotinic acid.
11. γ Ethyl-cresol.
12 α Benzoyl-cresol.
13. γ Benzoyl-cresol.
14. Potassium - α cresylsulphate.
15. Potassium - γ cresylsulphate.
16. Barium - γ cresylsulphite.
17. Potassium - α cresylsulphite.
18. Barium - α cresylsulphite.
19. Barium-sulphocresylate.
20. Potassium-bisulphocresylate.
21. β Benzokresid, $C_7H_7O(C_7H_5O)$.
22. Potassium - α thymolsulphate.
23. Barium - α thymolsulphate.
24. Phosphate of thymol.
25. Potassium - β thymolsulphate.
26. Potassium-thiobenzoate.
27. Barium-thiobenzoate.
28. Thiobenzoic-ethylic-ether.
29. Thiobenzoic-amylic-ether.
30. Thiobenzoic anhydride.
31. Dithiobenzoate of silver.
32. Tetrachlorbenzol.
33. Benzoylbisulphide.
34. Binitrophenol.
35. Picrylchloride.
36. Picrotoluid.
37. Binitrophenyltoluid.
38. Propylenbromide.

Engelhardt and Latschinoff.

39. Toluidinsulphuric acid, $C_7H_9NSO_3 + \frac{1}{2}H_2O$.
40. Toluidinsulphuric acid, $C_7H_9NSO_3 + H_2O$.

Malyscheff.

41. $N\left\{\begin{array}{l}C_7H_7SO_2m.\\C_7H_5O.\\H\end{array}\right.$
42. $N\left\{\begin{array}{l}C_7H_7SO_2p.\\C_7H_5O.\\H\end{array}\right.$
43. α Cresol.
44. α Methyl-cresol.
46. β Cresol.
47. β Ethyle-cresol.
48. Cresol-phosphate.

49. *p* Cresylsulphuric chloride.
50. *p* Cresylsulphuric amide.
51. Nitrocresylsulphuric amide.
52. $C_7H_7(NHKSO_2)p$.
53. $C_7H_6(NH_2)m(SHO_3)p + H_2O$.
54. *m* Cresylsulphuric amide.
55. $C_7H_7(NHKSO_2)m$.

Miss A. Wolkoff.

Rakowitsch's apparatus for determination of alcohol and sugar in liqueurs, as well as of the fat in butter, and for determination of water.

R. Nippe.

2536b. Preparations from Acids (**8**), by Sokolow and Latschinow (from acids).

Chemical Laboratory of the Agricultural Institute of St. Petersburg.

1. Hydrochlorate of diacetonhydramine.
2. Chloroplatinate of the above.
3. Neutral oxalate.
4. Bioxalate.
5. Bioxalate.
6. Picrate.
7. Chloroplatinate of the triacetonhydramin.
8. Chloroplatinate of triacetonamin.

Sokolow and Latschinow.

2536c. Chemical Preparations (**80**) from the works of Butleroff, Menschutkin, Gustavson, Lwoff, Wazne, Wyschnegradsky, Jermalajew, Popoff, Prianichnikoff, Nakapetian, Gagarin. *Chemical Laboratory, University of St. Petersburg.*

1. Uramidobenzoic acid.
2. Uramidobenzamide.

Both compounds illustrate the action of Potassiumcyanate on Amido-acids.

3. Mercury- and silver-compound of the succinamide.
4. Aethylsuccinamide and Methylsuccinamide.
5. Succinanil.
6. Succinamid-mercuric oxide, $C_4H_4O_2(NH_2)_2HgO, \frac{1}{2}aq$.
7. Phenylsuccinamide.
8. Succinanilide.
9. Salts of the succinamic acid.
10. Succinanilic acid.
11. Bariumsuccinanilate $[C_4H_4O_2(C_6H_5)HN]_2CaO_2 + 4H_2O$.
12. Calciumsuccinanilate.
13. Leadsuccinanilate (No. 5–13 comp. Liebig's Annalen, 162, 165).
14. Ammonium-parabanate.
15. Oxaluramid.
16. Potassium-parabanate.
17. Potassium-oxalurate.
18. Silver-parabanate.
19. Silver-parabanate + aq. (No. 14–19 comp. Liebig's Annalen, 172.)
20. Dimethylparabanic acid.
21. Ethyl-succidcyanate.
22. Methyl-succidcyanate.
23. Ethylsuccinuric acid together with its ammonium- and silver-salts.
24. Ethylsuccinuramid (No. 20–24 comp. Liebig's Annalen, 174).
25. Dialurate of Ammonium and of Potassium.
26. Ammonium-dialurate.
27. Sodium-dialurate.
28. Several Dialurates.
29. Tartronamic acid.
30. Tartronamates of barium, potassium and silver.
31. Tartronamate of lead.

W. Menschutkin.

32. Heyamethylenamine (Liebig's Ann. 144).
33. Oxymethylene (Liebig's Ann, 120).
36. Trimethylcarbinol (Liebig's Ann. 144, 162).
41. Pinakoline.
42. Cynonetol.
43. Isocrotylbromide.
44. Trimethylacetic acid.
45. Ethers of the above acid.
46. Potassium-trimethylacetate.

47. Silver-trimethylacetate.
48. Silver-trimethylacetate.
49. Ammonium-trimethylacetate.
50. Sodium-trimethylacetate.
51. Solution of zinc-trimethylacetate.
52. Zinc-salt and Cadmium-salt of the same acid.
53. Magnesium-salt.
54. Barium-salt.
55. Calcium-salt.
56. Mercury-salt.
57. Lead-salt.
58. Copper-salt.
59. Trimethylacetamide.
66. Trimethylacetic anhydride.
61. Pentamethylated ethylic alcohol.
62. Pentamethylaetholhydrat, $C_2(CH_3)_5OH + H_2O$.
63. Pentamethylated chloraethyl.
64. Pentamethylaetholhydrate.
68. Methylenchloride.
69. Di-isobutylene.

A. Butleroff.

34. Di-isopropoxalic acid.

Markovnikoff.

35. Tetraiodide of carbon.
39. Ethylideniodide.
40. Vinyliodide.

Gustavson.

37. Isohexylene.

Tschaikovsky.

38. Tetramethylformene.

Lwoff.

60. Dimethylethylacetate of silver.
71. Tertiary amylic alcohol.
72. Methylpropylcarbinol.
73. Tertiary amylic chloride.
74. Tertiary amylic iodide.
75. Ethylbutylpinakolin.
76. Ethylamylpinakolin.
80. Diamylene.

Wyschnegradsky.

64. Methylaethylcarbinol.

Wagner.

65. Isoamylen.

Jermalajew.

67. Triaethylcarbinol.

Nakapetian.

70. Dimethylaethylcarbinol, synthetic (Liebig's Ann. 145).

Popoff.

77. Dimethylisobutylcarbinol (Liebig's Ann. 162.)

Prianischnikoff.

78, 79. Aethylenjodbromide.

Prinz Gagarin.

2536d. Original Chemical Preparations (38), by C. Claus, obtained in his researches on Platina.

Chemical Laboratory, Imperial Berg-Institute, St. Petersburg.

(1.) $PtCy_2$.
(2.) $3KCl.OsO_2.SO_2$.
(3.) $2KCy.OsCy.3HO$.
(4.) $Ru_2Cl_3.3HCl$.
(5.) $2KCy.OsCy.3HO$.
(6.) $3NH_4Cl.Ir_2Cl_6$.
(7.) $3Hg_2Cl.Ir_2Cl_3$.
(8.) $3NH_4Cl.Ru_2Cl_6$.
(9.) Rh.
(10.) $3Hg_2Cl.Ir_2Cl_3$.
(11.) $3NH_4Cl.Ir_2Cl_3.3HO$.
(12.) $KCy.PtCy$.
(13.) $2KCy.RuCy.3HO$.
(14.) $KCy.PtCy.HO$.
(15.) $HgCy.PtCy.Hg_2ONO_5$.
(16.) $RuCy$.
(17.) $3KClRuCl_3$.
(18.) Silicate of Ruthenium and Potassium.
(19.) Ru_2S_3.
(20.) $KClRuCl_2$.
(21.) Ru_2O_33HO.
(22.) $RuCy$.
(23.) $2KCyRuCy$.
(24.) $3NH_4Cl.Ru_2Cl_3$.
(25.) Ru.
(26.) $2KCyRuCy3HO$.
(27.) $IrO_2.2HO$.
(28.) $Ru_2O_3.3LiO_3.KOSiO_3$.
(29.) $3NH_4O.SO_2.ZnO_2.SO_2.5HO$.
(30.) $IrCl_2.KCl$.
(31.) $2NH_4Cl.NH_4OSO_2$.

$$2IrO\left\{\begin{matrix}2SO_2\\Cl\end{matrix}\right\}12HO.$$

(32.) $3KCl.Ir_2Cl_3.3HO$.
(33.) $RuCl_2.KCl$.
(34.) $IrCl_2.KCl$.
(35.) $IrCl_2.KCl$.
(36.) $2KCl.IrOSO_2$.
(37.) $IrCy.2KCy$.
(38.) $3KCl.Ir_2Cl_3.6HO$.

Chem. Laboratory of the Imp. Mining Institute in St. Petersburg.

2536e. Chemical Preparations (3), by L. Chishkoff, obtained in his researches on **Fulminating Mercury.**

Chemical Laboratory, Michailoff Artillery Academy.

1. Dibromnitroacetonitril.
2. Potassium-isocyanurate.
3. Silver-isocyanurate.

L. Schischkoff.

2536f. Chemical Preparations (41), by Fritzshe and Zinin.

Chemical Laboratory, Imperial Academy of Sciences, St. Petersburg.

1, 2, 3. Crystallized Zinc.
4. Anthracene.
5. Chrysogen + naphtalene.
6. Chrysogen + anthracene.
7. Phosen + oxybinitrophosen.
8. Phosen + oxybinitrophosen.
9. Harmin. $C_{13}H_{12}N_2O$.

Staatsrath Fritzsche.

10. Lepidene.
11. Isolepidene.
12. Oxylepidene.
13. The same, Cryst. in leaves.
14. The same, Cryst. in needles.
15. 16. Bioxylepidene.
17. Hydroxylepidene.
18. Bichlorlepidene.
19. Bibromlepidene.
20. Bichloroxylepiden, needles.
21. Bichloroxylepiden, octaedric.
22. Bibromoxylepiden, needles.
23. Bibromoxylepiden, octaedric.
24. Hydrobichloroxylepiden.
25. Oxylepidinic acid.
26. Bichloroxylepidinic acid.
27. Benzoin.
28. Hydrobenzoin.
29. Desoxybenzoin.
30. Benzil.
31. Binitrotetrachlorbenzil.
32. Tetrachlorbenzil.
33. Chlorbenzil.
34. Formobenzoic acid.
35. Formobenzoilamid + Benzaldehyd.
36. Bichlortolan, in needles.
37. Bichlortolan, in leaves.
38. Harmalin, hydrocyanate.
39. Amaric acid.
40. Amaric anhydride.
41. Benzamaron, $C_{70}H_{56}O_4$.

Professor Zinin.

2536g. Chemical Preparations (124), by Beilstein, Kuhlberg, Kurbatoff, Hemilian, Rudneff, and 81 preparations by Wroblesky.

Chemical Laboratory, Technological Institute, St. Petersburg.

The methylic group occupies always the place 1.

1. $C_7H_6BrNO_2$. Boil. p. 255°—256°. $= C_6H_3\underset{4}{Br}\underset{3}{(NO_2)}.\underset{1}{CH_3}$.
2. $C_7H_6BrNO_2$. Fus. p. 55°. $= C_6H_3\underset{3}{Br}\underset{6}{(NO_2)}.\underset{1}{CH_3}$.
3. $C_7H_6\underset{3}{Br}\underset{6}{I}$. Boil. p. 260°.
4. α $C_7H_6\underset{4}{Cl}.\underset{2}{OC_2H_5}$. Boil. p. 210°.
5. β $C_7H_6Cl.OC_2H_5$. Boil. p. 210°.
6. $C_7H_3\underset{3}{Cl}\underset{(2,5,6)}{(NO_2)_3}.\underset{4}{OK}$.
7. $C_7H_3\underset{3}{Cl}\underset{(2,5,6)}{(NO_2)_3}\underset{4}{OH}$. Fus. p. 82·5°.
8. $C_6H_3(CH_3)_2OH$. Fus. p. 75°. Boil. p. 212·5°.
9. $C_6H_3(CH_3)_2OH$. Boil. p. 211·5°.

10. $C_6H_2\underset{3}{Br}\underset{4}{I}(\underset{5}{NO_2}).CH_3$. Fus. p. 118°.

11. $C_6H_2\underset{3}{Br}\underset{6}{I}(\underset{?}{NO_2}).CH_3$.

12. $C_6H_3\underset{3}{Cl}(\underset{?}{NO_2})CH_3$. Boil. p. 249°.

13. $C_6H_3\underset{3}{Br}\underset{4}{I}.CH_3$. Boil. p. 265°.

14. $C_6H_3\underset{3}{Br}(\underset{4}{NO_2})CH_3$. Boil. p. 269°.

15. $C_6H_3\underset{3}{Br}(\underset{5}{NO_2})CH_3$. Fus. p. 124°.

16. $C_6H_2\underset{(3,\,5)}{Br_2}(\underset{?}{NO_2}).CH_3$. Fus. p. 87·5°.

17. $C_6H_2\underset{(2,6)}{Br_2}(\underset{?}{NO_2})CH_3$. Fus. p. 79°.

18. $C_6H_2\underset{(3,\,4)}{Br_2}(\underset{?}{NO_2})CH_3$. Fus. p. 86°–87°.

19. $C_6H\underset{2}{Br}\underset{6}{Br}\underset{4}{Br}(\underset{3}{NO_2}).CH_3$. Fus. p. 215°.

20. $C_6H_2\underset{2}{Br}\underset{6}{Br}(\underset{?}{NO_2})CH_3$. Fus. p. 46°–47°.

21. $C_6H\underset{2}{Br}\underset{6}{Br}\underset{4}{Br}(\underset{3}{NH_2})CH_3$. Fus. p. 97°.

22. $C_6H_2\underset{2}{Br}\underset{6}{Br}.\underset{3}{NH_2}.CH_3$. Fus. p. 92·5°.

23. $C_6H_2\underset{2}{Br}\underset{6}{Br}.CH_3.\underset{3}{NH}.(C_2H_3O)$. Fus. p. 154°.

24. $C_6H_2\underset{3}{Br}\underset{5}{Br}.\underset{4}{NH_2}.CH_3$. Fus. p. 73°.

25. $C_6H_2\underset{1}{Br}\underset{5}{Br}\underset{?}{NH_2}CH_3$. Fus. p. 82°.

26. $C_6H_2\underset{3}{Br}\underset{5}{Br}\underset{?}{NH_2}.CH_3$. Fus. p. 95°.

27. $C_6H_2\underset{2}{Br}\underset{5}{Br}\underset{?}{NH_2}.CH_3$. Fus. p. 83°.

28. $C_6H_2\underset{3}{Br}\underset{5}{Br}\underset{2}{NH_2}.CH_3$. Fus. p. 50°.

29. $C_6H_3\underset{3}{Br}\underset{6}{NH_2}.CH_3.HNO_3$.

30. $C_6H_3\underset{3}{Br}\underset{6}{NH_3}CH_3.HCl$.

31. $(C_6H_3\underset{3}{Br}\underset{6}{NH_2}.CH_3)_2H_2SO_4 + 1\frac{1}{2}$ aq.

32. $C_6H_3\underset{3}{Br}\underset{6}{NH_2}.CH_3$. Fus. p. 57°.

33. $C_6H_3\underset{3}{Br}.CH_3.\underset{6}{NH}.C_2H_3O$. Fus. p. 156 .

34. β $(C_6H_2Br(NO_2)CH_3SO_3)_2Ba + 7$ aq.

35. β $(C_6H_2Br(NO_2)CH_3SO_3)_2Pb + 3$ aq.

36. β $(C_6H_2Br(NO_2)CH_3SO_3)_2Ca + 9$ aq.

37. β $(C_6H_3\underset{3}{Br}.\underset{6}{SO_3}.CH_3)_2Pb + 3$ aq.

38. β $C_6H_3\underset{3}{Br}.\underset{6}{SO_3}.CH_3.K$.

39. $(C_6H_3\underset{4}{Cl}.CH_3.\underset{2}{SO_3})_2Ba + 2$ aq.

40. $(C_6H_2\underset{4}{Cl}(\underset{?}{NO_2}) . CH_3 . \underset{?}{SO_3})_2Ba$.

41. $C_6H_2\underset{3}{Br}\underset{5}{Br}\underset{4}{I} . CH_3$. Fus. p. 86°; boil. p. 270°.

42. $C_6H_4Br . CH_3$. Boil. p. 182°.

43. $C_6H_4\underset{3}{Cl} . CH_3$. Boil. p. 157°.

44. $C_6H_2Br_3 . CH_3$. Fus. p. 70°.

45. $C_6H_3\underset{2}{Br}\underset{5}{Br} . CH_3$. Boil. p. 238°

46. $C_6H_3\underset{3}{Br}\underset{4}{Br} . CH_3$. Boil. p. 237°.

47. $C_6H_3\underset{2}{Br}\underset{6}{Br} . CH_3$. Boil. p. 246°.

48. $C_6H_3\underset{3}{Br}\underset{5}{Br} . CH_3$. Fus. p. 60°.

49. $C_6H_3\underset{2}{Br}\underset{3}{Br} . CH_3$. Fus. p. 42·5°.

50. $C_6H_3\underset{1,3}{(CH_3)_2}\underset{5}{C_2H_5}$. Boil. p. 185°.

51. $C_6H_4 . CH_3 . \underset{3}{C_2H_5}$. Boil. p. 157°.

52. $C_6H_3\underset{3}{Cl} . (\underset{4}{NH} . C_2H_3O) . CH_3$. Fus. 99°.

53. $C_6H_3\underset{3}{Cl} . CH_3 . \underset{4}{NH_2} . HCl$.

54. $C_6H_3\underset{3}{Cl} . CH_3 . \underset{4}{NH_2} . HNO_3$.

55. $(C_6H_3\underset{3}{Cl} . CH_3 . \underset{4}{NH_2})_2 . H_2SO_4$.

56. $(C_6H_3\underset{3}{Cl} . CH_3 . \underset{4}{NH_2})_2 . C_2H_2O_4$.

57. $C_6H_3\underset{3}{Br} . \underset{4}{NH}(C_2H_3O) . CH_3$. Fus. p. 117·5°.

58. $C_6H_3\underset{3}{Br}(CH_3)\underset{4}{NH_2} . HCl$.

59. $C_6H_3\underset{3}{Br}(CH_3)\underset{4}{NH_2} . HNO_3$.

60. $(C_6H_3\underset{3}{Br}(CH_3) . \underset{4}{NH_2})_2 . H_2SO_4$.

61. $(C_6H_3\underset{3}{Br}(CH_3) . \underset{4}{NH_2})_2C_2H_2O_4$.

62. $C_6H_2\underset{3}{Br}(\underset{5}{NO_2})CH_3 . \underset{4}{NH}(C_2H_3O)$. Fus. p. 210·5°.

63. $C_6H_2\underset{3}{Br}(\underset{5}{NO_2})CH_3 . \underset{4}{NH_2}$. Fus. p. 64·5°.

64. $C_6H_3\underset{3}{Br}(\underset{5}{NO_2})CH_3$. Fus. p. 86°; boil. p. 279°.

65. $C_6H_3\underset{3}{Br} . CH_3\underset{5}{NH_2}$. Boil. p. 265°.

66. $C_6H_3\underset{3}{Br} . CH_3 . \underset{5}{NH_2} . HNO_3$.

67. $C_6H_3\underset{3}{Br} . CH_3 . \underset{5}{NH_2} . HCl$.

68. $(C_6H_2\underset{3}{Br} . CH_3 . \underset{5}{NH_2})_2H_2SO_4$.

69. $C_6H_4\underset{5}{Br} . \underset{1}{CO_2H}$. Fus. p. 154°.

70. β $C_6H_3\underset{4}{Cl} . \underset{?}{NH_2} . CH_3$. Fus. p. 83°; boil. p. 241°.

71. β $C_6H_3\underset{4}{Cl} . \underset{?}{NH_2} . CH_3 . HCl$.

72. β $C_6H_3\underset{4}{Cl} . \underset{?}{NH_2} . CH_3 . HNO_3$.

73. β $C_6H_3\underset{4}{Cl}(\underset{?}{NO_2})CH_3$. Boil. p. 253°.

74. β $C_6H_3\underset{4}{Cl} . I . CH_3$. Boil. p. 240°.

75. α $C_6H_3\underset{4}{Cl} . CH_3 . \underset{?}{NH_2}$. Boil. p. 238°.

76. α $(C_6H_3\underset{4}{Cl} . CH_3 . \underset{?}{NH_2})HCl$.

77. α $C_6H_3\underset{4}{Cl} . CH_3 . \underset{?}{NH_2})HNO_3$.

78. α $C_6H_3\underset{4}{Cl}CH_3 . NO_2$. Boil. p. 243°.

79. $C_6H_2\underset{3, 4}{Cl_2}(\underset{?}{NO_2})CH_3$. Boil. p. 274°.

80. $C_6H_2\underset{3, 4}{Cl_2}(\underset{?}{NH_2}) . CH_3$. Fus. p. 88°; boil. p. 259°.

Wroblevsky.

1. Orthonitrocinnamates.
2. Orthonitrocinnamic ethers.
3. Orthonitrobenzoic ether and Orthonitrobenzoic amide.
4. Trichlorbenzoate of barium.
5. Trichlorbenzoate of ethyle.
6. Trichlorbenzoate of ammonium.
7. Trichlorbenzoate of calcium.
8. Trichlorbenzoic acid.
9. Trichlorbenzoic amide.
10. Trichlorbenzoic aldehyde.

11. }
12. } No. 4–12 of Liebig's Ann. 152.

13–28. Chlorine derivatives of Toluene (Liebig's Ann. 146, 150, 152).
  (1.) $C_6H_4Cl . CH_3$.
  (2.) $C_6H_3Cl_2 . CH_2Cl$.
  (3.) $C_6H_2Cl_3 . CH_3$.
  (4.) $C_6H_3Cl_2 . CHCl_2$.
  (5.) $C_6H_4Cl . CH_3$.
  (6.) $C_6H_2Cl_3 . CH_2Cl$.
  (7.) $C_6H_4Cl . CCl_3$.
  (8.) $C_6Cl_5CH_3$.
  (9.) $C_6H_3Cl_2 . CCl_3$.
  (10.) $C_6H_2Cl_3 . CHCl_2$.
  (11.) $C_6HCl_4 . CH_2Cl$.
  (12.) $C_6H_2Cl_3 . CCl_3$.
  (13.) $C_6Cl_5 . CH_2Cl$.
  (14.) $C_6HCl_4 . CHCl_2$.
  (15.) $C_6HCl_4 . CCl_3$.
  (16.) $C_6Cl_5 . CHCl_2$.

29–34. Substituted Benzylic alcohols (Liebig's Ann. 147).
  (1.) $C_6H_4Cl . CH_2 . OH$.
  (2.) $C_6H_3Cl_2 . CH_2OH$.
  (3.) $C_6H_2Cl_3 . CH_2 . OH$.
  (4.) $C_6HCl_4 . CH_2 . OH$.
  (5.) $C_6Cl_5 . CH_2 . OH$.
  (6.) $C_6H_3(NO_2)_2 . CH_2 . OH$.

35. α Nitronaphtalidine.

36. Trinitronaphtalene (35 and 36 comp. Liebig's Ann. 169).

37–39. Toluylendiamine (Liebig's Ann. 158).
  (1.) $C_6H_3(NH_2)p(NH_2)m.CH_3$.
  (2.) Sulphate.
  (3.) Stannous chloride double salt.

40–53. Derivatives of Toluene and Nitrotoluene (Liebig's Ann. 155).
  (1.) *m* Nitro—*o* Acettoluid.
  (2.) *m* Nitro—*o* Toluidine.
  (3.) *m* Nitro—*p* Acettoluid.
  (4.) *m* Nitro—*p* Toluidine.
  (5.) *o* Nitro—*m* Acettoluid.
  (6.) *o* Nitro—*m* Toluidine.
  (7.) Dinitro—*p* Acettoluid.
  (8.) Dinitro—*p* Toluidine.
  (9.) *o* Nitro—*p* Toluidine.
  (10.) *m* Nitrotoluene.
  (11.) *m* Nitro—*p* Bromtoluene.

(12.) Dinitrotoluene (Fus. p. 60·5°).
(13.) Trinotrotoluene (Fus. p. 77°–80°).

Beilstein and Kuhlberg.

54. α Dichlorbenzoic acid.
55. Calcium-salt.
56. Barium-salt.
57. α Dichlorbenzoic amide.
58. β Dichlorbenzoic acid.
59. Calcium salt.
60. Barium-salt.
61. β Dichlorbenzoic amide (No. 54–61 of Liebig's Ann. 179).

Beilstein.

62–82. Derivatives of Aniline (Liebig's Ann. 176).
(1.) $C_6H_3\underset{1}{Cl}.\underset{4}{NH_2}.\underset{3}{NO_2}$
(2.) $C_6H_3\underset{3}{Cl}.\underset{1}{NH_2}.\underset{5}{NO_2}$.
(3.) Acetylic compound of No. 2.
(4, 5.) $C_6H_3\underset{2}{Cl}.\underset{5}{NO_2}.\underset{4}{NH_2}$.
(6.) $C_6H_3.\underset{1}{NO_2}.\underset{4}{NH_2}.\underset{2}{Cl}$.
(7.) Acetylic compound of No. 6.
(8.) $C_6H_2\underset{3}{Cl}\underset{4}{Cl}.\underset{6}{NO_2}.\underset{1}{NH_2}$.
(9.) Dichloraniline (1, 4—2).
(10.) Dichloranilin (1, 2—4).
(11.) Acetylic derivative of No. 10.
(12.) Acetylic compound of Dichloranilin (1, 3—4).
(13.) Picrate of *p* Chloranilin.
(14.) Picrate of Chloranilin.
(15.) *m* Chloracetanilid.
(16.) *o* Chloracentailid.
(17.) Trichloranilin (1, 2, 3—4).
(18.) Trichloranilin (2, 4, 6—1).
(19.) Trichloranilin (1, 2, 3—5).
(20.) Trichloranilin (1, 2, 5—4).

83–87. *o* Dichlorbenzolsulphonic acid.
88. $C_6H_3\underset{1}{Cl}\underset{2}{Cl}(\underset{4}{NO_2})$.
89. *m* Dichlorbenzol.
90. $C_6H_3\underset{1}{Cl}\underset{3}{Cl}(\underset{4}{NO_2})$.
91. *m* Dichlorbenzolsulphonic acid.
92. *o* Chlornitrobenzol.
93. $C_6H_3Cl_3$ (1, 3, 5).
94. $C_6H_3Cl_5$ (1, 2, 3).
95. $C_6H_2\underset{1}{Cl}\underset{2}{Cl}\underset{3}{Cl}(\underset{5}{NO_2})$.
96. $C_6H_2Cl_4$ (1, 3, 4, 5).
97. $C_6H\underset{1}{Cl}\underset{3}{Cl}\underset{4}{Cl}\underset{5}{Cl}(\underset{2}{NO_2})$.
98–101. Trichlorphenylguanidin and Salts.

Beilstein and Kurbatoff.

102. Dinitroacetanilid.
103. Dinitrocitraconanil.
104. Citraconanil.
105. Dinitroanilin.
106. Parasulfocinnamic acid.
107. Parasulfocinnamate of Barium.
108. Acid metasulfocinnamate of Barium.

Rudnew.

109. Barium-sulfobutyrate.
110. Calcium-sulfobutyrate.
111. Silver-sulfobutyrate.
112. Copper-sulfobutyrate.
113. Lead-sulfobutyrate.
114. Zinc-sulfobutyrate.
115. Triphenylmethan.
116. Triphenylmethan with Benzol.
117. Diphenyltolylmethan.
118. Naphtyldiphenylmethan.
119. Diphenyl-phenylenmethan.
120. Triphenylcarbinol.
121. Triphenylcarbinol-ethylic ether.
122. Benzhydrolbenzoic acid.
123. Barium salt.
124. Trinitrotriphenylmethan.

Hemilian.

125. Magnesium-cuminate $(C_{10}H_{11}O_2)_2Mg.6H_2O$.
126. Calcium - cuminate $(C_{10}H_{11}O_2)_2Ca.3H_2O$.
127. Barium - cuminate $(C_{10}H_{11}O_2)_2Ba.2H_2O$.

Beilstein and Kupffer.

2536h. Pyroxyline. Detection of poisons in medico-legal investigations. *N. W. Sokoloff.*

2536h. Chemical Laboratory of the Imp. Medic. Surg. Academy. 45 Flasks containing organic bodies remaining after the researches made by Professor A. Borodin and by others under his direction.

1. Acetic ether of isocapric alcohol, $(C_2H_3O)(C_{10}H_{21})O$. (Jahresbericht für Chemie, 1864, 338.)
2. Aldehyde of isocapric alcohol, $C_{10}H_{20}O$. (Jahresb. f. Ch. 1870, 680.)
3. Condensation product of the valeral (divaleral), $C_{10}H_{20}O_2$. (Berichte der Deutsch. Chem. Gesellschaft. V. 480.)
4. Hydrate of divaleral, $(C_{10}H_{20}O_2)_2H_2O$. (*Ibidem,* VI. 982.)
5. Condensation product of valeral-aldehyde, $C_{10}H_{18}O$. (*Ibid.* V. 480.)
6. Acid from the aldehyde, $C_{10}H_{18}O$. ($C_{10}H_{18}O_2$.) (*Ibid.*)
7. Condensation product of the valeral, ($C_{20}H_{38}O_2$. (*Ibid.*)
8. Base, isomeric with the cuminhydramide ($C_{30}H_{36}N_2$), crystallized from alcohol. (Ibid. VI. 1,253.)
9. The same crystallized from benzine. (*Ibid.*)
10. Hydrochlorate of the base. ($C_{30}H_{36}N_2 . ClH$.)
11. Sulphate of the base, crystallized from alcohol, $(C_{30}H_{36}N_2)_2H_2SO_4$.
12. The same crystallized from alcohol acidulated with sulfuric acid.
13. Nitrate of the base. ($C_{30}H_{36}N_2 . HNO_3$.) (*Ibid.*)
14. Nitrosoamarin. ($C_{21}H_{12}(NO)N_2$). (*Ibid.* VIII. 933.)
15. Sulphocarbobenzidide, ($C_{12}H_{10}(CS)N_2$). (Jaresb. f. Chem. 1860, 356.)

A. Borodin.

16. Cerotic acid (from the bees-wax), fusing at 91° ($C_{34}H_{68}O_2$?). (Bericht der Deutsch. Chem. Gesell. IX. 278).
17. Pelargonamide, $(C_9H_{14}O)N_7H_2$. (*Ibid.* VI. 1252.)

Dr. M. Schalfejeff.

18. Amido-desoxybenzoine ($C_{14}H_{11}(NH_2)O$) crystallized from alcohol.
19. The same from its hydrochlorate.
20. Hydrochlorate of amido-desoxybenzoine. ($C_{14}H_{11}(NH_2)O.HCl$).
21. Oxalate of amido-desoxybenzoine, $(C_{14}H_{11}(NH_2)O)_2C_2H_2O_4$. (*Ibid.* VI. 1253.)

Dr. P. Goloubeff.

22. Succinyl-dibenzoine, $(C_{14}H_{11}O_2)_2C_4H_4O_2$. (*Ibid.* V. 331.)

Mrs. Adelaida Lukanin.

23. Potassium-sulphocetenate, $(C_{16}H_{31}SO_3)K$.
24. Magnesium-sulphocetenate, $(C_{16}H_{31}SO_3)_2$ Mg.
25. Ferrous sulphocetenate, $(C_{16}H_{31}SO_3)_2Fe$.
26. Zinc-sulphocetenate, $(C_{16}H_{31}SO_3)_2$ Zn.
27. Cupric sulphocetenate, $(C_{16}H_{21}SO_3)_2Cu$.
28. Argentic sulphocetenate, $(C_{16}H_{31}SO_3)Ag$.
29. Uranic sulphocetenate. (*Ibid.* VII. 125.)

Dr. P. Lazorenco.

30. Mono-iodophenol ($C_6H_4I(HO)$), fusing at 64°–66°.
31. Isomeric mono-iodophenol, fusing at 89°.
32. Tri-iodophenol, $C_6H_2l_3(HO)$.
33. Isomeric fluid mono-iodophenol. (*Ibid.* VI. 1251.)

Dr. C. Lobanoff.

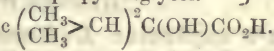
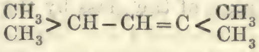
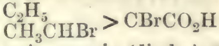
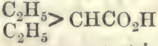
34. α Dinaphtol, $C_{20}H_{12}(HO)_2$. (*Ibid.* VII. 125, VI. 1252.)
35. Dibenzoyl-α-dinaphtol, $C_{20}H_{12}(C_7H_5O . O)_2$. (*Ibid.* VII. 487.)
36. β Dinaphtol, ($C_{20}H_{12}(HO)_2$). (*Ibid.* VI. 1252.)
37. Mono-benzoyl-β-dinaphtol. ($C_{20}H_{12}(C_7H_5O . O)(HO)$.) (*Ibid.* VII. 125.)
38. Dibenzoyl-β-dinaphtol, $C_{20}H_{12}(C_7H_5O . O)_2$. (*Ibid.*)
39. β Oxydinaphtylene. ($C_{20}H_{12}O$.) (*Ibid.* VIII. 166.)
40. Picrate of β oxydinaphtylene. ($C_{20}H_{12}O . C_6H_2(NO_2)_3HO$.) (*Ibid.*)
41. Dithymol, $C_{20}H_{24}(HO)_2H_2O$. (*Ibib.* VIII. 166.)
42. Dibenzoyl-dithymol, $C_{20}H_{24}(C_7H_5O . O)_2$. (*Ibid.*)

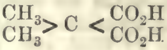
Mr. A. Dianin.

43. Dinitro-diphenol, $C_{12}H_6(NO_2)_2(HO)_2$. (Jahresbericht für Chemie, 1874, 466.) *Mr. M. Goldstein.*
44. Nitrobenzoylanilide, $(C_7H_5(NO_2))C_6H_5N$.
45. Benzoylnitranilide, $(C_7H_6)C_6H_4(NO_2)N$. (Jahresb. f. Ch. 1870, 759.) *Dr. P. Lazerenco.*
46 Apparatus for a new and simplified method of quantitative estimation of urea, by means of sodium hypobromite. (Will be published.) *Prof. A. Borodin.*

2536i. Collection of Chemicals (39).

The Imperial Moscow University, Moscow.

1. Ac. isobutyric. (The first isomeric acid discovered among the monobasic acids (synthetic).	Annalen der Chemie und Pharmacie, B. 138, par V. Markovnikoff.
2. Isobutyrate of calcium.	
3. Isobutyr. of plumb.	
4. Isobutyr. of argent.	
5. Isobutyr. of ethyl.	
5*a*. Chlorure of isobutyrile.	
6. Ether ethyl pseudopropylic.	
7. Ac. bromisobutyric.	Annalen der Chemie und Pharmacie, B. 153, par V. Markovnikoff.
8. Oxyisobutyrate of calcium.	
9. Oxyisobutyrate of zinc.	
10. Chlorure of butyrylechlory.	
11. Oxybutyrate of zinc.	
12. Bromhydrine of pseudopropyleneglycol.	
13. Ac. oxyisocaprylic  $\left({CH_3 \atop CH_3}>CH\right)^2C(OH)CO_2H$.	Journale de la Société Chimique Russe, v. II. (1870).
14. Ether oxyisocaprylic.	
15. Pseudoheptylene  ${CH_3 \atop CH_3}>CH-CH=C<{CH_3 \atop CH_3}$.	Journ. de la Soc. Chim. Russe, III. (1871), par V. Markovnikoff.
16. Dichloracetane $CH_2ClCOCH_2Cl$	Journ. de la Soc. Ch. Russe, V., par V. Markovnikoff.
17. Ac. dibromisocaproic  ${C_2H_5 \atop CH_3CHBr}>CBrCO_2H$	Journ. de la Soc. Chim. Russe, V.; Berichte der Deutsch. Chem. Geselsch, VI., par V. Markovnikoff et Drobjazgine.
18. Ac. isocaproic (diethylacetic)  ${C_2H_5 \atop C_2H_5}>CHCO_2H$	

19. Ac. oxypyrotartric normal (glutanic).
20. Glutanate of zinc.
21. Glutanate of magnesium.
22. Ac. pyrotartric normal (synthetic) $(CH_2)^2(CO_2H)^2$.
23. Ac. pyrotartric normal (by reduction).
24. Pyrotartrate of magnesium (normal).
25. Ac. ethylmalonic (α pyrotartric).
26. α Pyrotartrate of zinc.
27. α Pyrotartrate of ethyl.
28. Ac. dimethylmalonic (β pyrotartric)  ${CH_3 \atop CH_3}>C<{CO_2H \atop CO_2H}$
29. β Pyrotartrate of plumb.
30. Ether bromisobutyric.
31. Iodure of pseudoprapyle. Zeitsch für Chemie, 1865, Ann. d. Ch. u. Ph., B. 138, par V. Markovnikoff.

32. Iodure of acetylene $C_2H_2I_2$.
33. Bibromure of acetylene.
34. Tetrabromure of acetylene.
35. Acetylene triphenyltriamine.
} Ann. der Ch. u. Ph., B. 178, par A. Sabanejeff.
36. Oxychlorure of antimony SbOCl } Journ. de la Soc. Russe, par A. Sabanejeff.
37. Isodibromantracene $C_6H_4C_2H_2C_6H_2Br_2$.

2536r. Chemical Reagents, &c. A series of 835 specimens of those employed in scientific research. Not specially prepared for exhibition. *Hopkins & Williams.*

2678. Digester, made of cast-steel, for digesting under pressure. It holds 4 litres, is silvered inside and coppered outside. Manufactured by Fr. Krupp, of Essen.
Prof. H. Landolt, Aix-la-Chapelle.

2588. Diagram, showing elevation, section, and plan of a "digestorium" (iron closet constructed for effecting dangerous digesting operations).
Chemical Institute of the University of Strassburg, Elsass.

2584. Instrument for **Calculating Atomic and Volumetrical combinations,** to 4 places of logarithms.
Rudolph Weber, Aschaffenburg.

2456s. Bunsen's explosion Eudiometer, with the wire cut off, and ground flush with the external surface of the tube in order to prevent straining of the glass by the bending of the wires.
Prof. H. McLeod.

When an explosion has to be made the wires are connected to an induction coil by the help of a wooden paper-clip with strips of platinum foil fastened inside it, each strip being provided with a wire loop to which the conducting wires from the coil may be attached.

2456l. Regnault's Eudiometer.
Golaz, 22 Rue des Fosses, St. Jacques, Paris.

This apparatus is made of a triangular iron stand, and is furnished with a set screw for fixing to the upright a slide moved by rackwork ; a vessel of mercury is fixed upon the slide, and can consequently be raised or lowered to the height required. On the opposite side of the iron upright is fixed a plate provided with an iron stop-cock and two tubes. In one of these tubes is cemented a straight tube, open at its ends, and divided into millimetres throughout its length. In the other tube is cemented a tube, terminating at its upper extremity by a capillary glass tube, and bent horizontally ; this tube is divided into millimetres, and is traversed at its upper part by two platinum wires, through which the electric spark is made to pass. The whole of this manometer apparatus is surrounded with a glass cylinder 15 centimetres in diameter to be filled with water, in order to keep the manometer at a uniform temperature. The second portion of the apparatus consists of the experimental tube in which the gases are submitted to the various absorbents ; this eudiometer is thus composed of two distinct parts:—1. The measuring tube, in which the gases are measured under determined conditions of temperature and moisture. 2. The experimental tube. The upper part of the iron upright is furnished with a copper carrier, to which is fixed a steel stop-cock, which is connected with another similar one by means of a collar. The stop-cock fixed to the carrier is cemented to the measuring tube which dips into the cylinder; the second steel stop-cock is cemented to the experimental tube, and dips into the vessel of mercury. It can be seen by this arrangement that it is easy to connect or disconnect the experimental tube and the measuring tube, to make the gas pass from the experimental tube into the measuring tube, or to make the mercury run into either of the two tubes of the manometer apparatus, as is explained by M. Regnault, vol. 4, p. 73, "Cours de Chemie Elementaire."

2456m. Regnault's Apparatus for measuring the Coefficients of expansion of Gas.

Golaz, 22 Rue des Fosses, St. Jacques, Paris.

This apparatus consists of two distinct parts, a boiler and a manometer The boiler is a brass vessel in which either water or ice is placed, it is closed by a cover provided with a tube by which the vapour may escape, and is supported by a cast-iron stand on which it can be raised or lowered; it is also capable of motion in a horizontal groove, which allows of its being advanced or withdrawn.

A large alcohol lamp, which is also capable of being raised or lowered, is used for heating the water.

The manometer consists of a mahogany board fixed to an iron stand supporting an iron framework furnished with two vertical tubes connected by a three-way cock; by this means communication can be established between the two tubes or with the outside air. Thus the mercury can be made either to pass from one tube into the other, or to flow away from either into the outside air. Into one of the tubes is cemented a glass tube with millimetre graduations, and ending at its upper part in a capillary glass tube; the second tube is graduated like the first, and terminates in an opening, which constitutes an open manometer. The capillary ending of the first tube is closed by a steel three-way cock.

A glass globe of about three-quarter litre capacity is fixed in the heater, and into it is introduced the gas to be investigated. The globe is attached to the stop-cock of the manometer by means of a copper capillary tube, the flexibility of which renders the adjustment of the apparatus easy. In the first apparatus of this description constructed the tube was of glass and cemented to the globe, but this method was found to render the formation of a proper joint very difficult.

The details of the experiments made with the apparatus are to be found in the "Mémoires de l'Académie des Sciences," tome 21, page 96, and plate 1, fig. 7."

For this second method the same boiler and globe are employed. The manometer alone is different. It is composed of two tubes, the first having a large diameter for the greater part of its length, and ending in a capillary tube attached to a steel stop-cock, the second tube is open at its upper end. This part of the apparatus is enclosed in a case of strong canvas, provided with a glass side, thus permitting the manometer to be kept at a constant temperature, and the progress the experiment at the same time to be watched.

The capillary tube of the globe in the boiler is connected with the steel stop-cock of this apparatus.

An air-pump or pneumatic apparatus is put into communication with the third tube of the two stop-cocks, and serves to dry the globe and the tube of the manometer, by taking care to turn the lower stop-cock in such a way as to render impossible the rise of the mercury in the tube of the manometer.

2456p. Regnault's Apparatus for determining the Tension of Steam at high pressure.

Golaz, 24 *Rue des Fosses, St. Jacques, Paris.*

This apparatus consists of four parts, 1, the boiler; 2, the reservoir of compressed air; 3, the manometer; 4, the force pump.

1. The boiler is a cylinder with hemispherical ends. The upper portion is traversed by two tubes fixed in it, and which are prolonged into the cylinder. In these tubes are placed the thermometers indicating the temperature of the steam.

The cylinder is connected with a horizontal tube surrounded by another cylinder which forms a refrigerator for the tubes, and is so placed as to be able to furnish a constant current of water. At the extremity of this tube is an arrangement for connecting the apparatus to the reservoir of compressed air.

2. The compressed air reservoir is of a cylindrical shape; at the lower part there is a junction for the attachment of a leaden tube which connects it with the boiler. At the upper part are two stop-cocks connecting it respectively with the manometer and the force pump. This pressure reservoir is surrounded by a cylinder filled with water to keep it at an equable temperature.

3. The manometer is fitted with a cast-iron reservoir, and a force pump with which the mercury is forced into the tubes; a stop-cock is closed when the mercury has risen to the height desired. A three-way cock allows the compressed air to escape from the reservoir.

The upper part of the pressure tube of the manometer is put in connection with the compressed air reservoir by a small flexible leaden tube provided with the necessary stop-cocks.

4. The compression pump is worked by a shaft provided with a fly-wheel and winch handle, and with it one man can readily obtain a pressure of 15 or 20 atmospheres. The valves are of leather, and are thus easily replaced in case of derangement.

For details of the apparatus and of the experiments made with it, see " Mémoire de l'Académie", t. 21 (vol. 21). This apparatus was made by the exhibitor for M. Regnault at the time of his first experiments.

2456q. Regnault's Apparatus for determining the Tension of Vapour from 0° to 100°.

Golaz, 24 *Rue des Fosses, St. Jacques, Paris.*

This apparatus consists of a sheet iron vessel furnished with an agitator, one side of it being formed of a pane of thick glass, so that all that is going on inside may be seen. A cylinder is supported on an iron frame, upon which are placed a mercury vessel, a screen, and an alcohol lamp; two barometrical tubes enter the vessel, one being a standard barometer, and the other terminating at its upper end in a horizontal tube, whilst to the other end a glass globe can be readily attached by means of a suitable mounting. In the middle of the horizontal tube is placed a stop-cock by means of which the globe and the barometrical tube can be emptied. In the globe is placed the substance, the vapour tension of which is to be investigated. See " Mém. de l'Acad." t. 21, vol. 21.

2456r. Apparatus for compression of Liquids by Regnault's Piezometer.

Golaz, 24 Rue des Fosses, St. Jacques, Paris.

This apparatus, constructed by the exhibitor for M. Regnault, consists of a thick copper cylinder closed at its upper part by a copper plate bolted to the circumference and provided with three tubes. To the central tube is cemented the glass stem of the piezometer. The right hand tube has a stop-cock which opens into the atmosphere and serves for relieving the pressure; the left-hand tube has also a stop-cock which is attached by a leaden tube to a block fitted with two other stop-cocks at right angles to it, and which is cemented at the other end to the stem of the piezometer; the other branch is connected with a compression pump or a pressure reservoir. The cylinder is first filled with water by means of the two upper stop-cocks, and pressure can then be applied under all the conditions indicated by M. Regnault. "Mém. de l'Acad." t. 21.

III. APPARATUS USED IN ANALYSIS.

2456. Apparatus used in the Analysis of Drinking Water.

E. Frankland, F.R.S.

For full particulars, see Journ. of Chem. Soc. for March 1868 and June 1876.

1. Determination of total solid constituents or total solid impurity.

Platinum capsule in which half a litre of the water is evaporated to dryness, and the residue weighed.

2. Determination of organic carbon and organic nitrogen.

A. Apparatus in which one litre of the water is first heated to boiling with sulphurous acid, and then evaporated to dryness.
B. Steel spatula for scraping out the dry residue from the glass capsule.
C. Cupric oxide for the combustion of the organic matter in the dry residue.
D. Piece of hard glass tube ready to receive the mixture of dry residue, cupric oxide, and metallic copper for combustion.
E. Combustion tube charged and drawn out ready to be placed in furnace.
F. Sprengel mercurial pump for extracting air from combustion tube before the ignition of the mixture of dry residue and cupric oxide, and for extracting the gases from the same tube after ignition.
G. Hofmann's gas furnace, containing a pair of charged tubes ready for combustion.
H. Pair of inverted glass tubes for the collection of the gases produced by the combustion of the organic matter and ammonia in the solid residue.
I. Apparatus for the analysis of the gases collected in the tubes H.

3. Determination of nitrogen in the form of nitrates and nitrites.

This is effected by dissolving, in a small quantity of distilled water, the solid constituents obtained in determination No. 1, and adding a slight excess of argentic sulphate to convert the chlorides into sulphates. The filtered liquid is then concentrated to a small bulk, mixed with rather more than its own volume of concentrated sulphuric acid, and then introduced over mercury into the tube K, through the cup and stop-cock. The lower end of the tube is now firmly closed by the thumb, and the contents violently agitated by a simultaneous vertical and lateral movement, in such a manner as always to leave an unbroken column of mercury, at least an inch long, between the acid liquid and the thumb. In about a minute from the commencement of the agitation a strong pressure begins to be felt against the thumb of the operator, and mercury spurts out in minute streams as nitric oxide gas is evolved. In from three to five minutes the re-action is completed, and the nitric oxide evolved must then be transferred for measurement to the apparatus No. 2 I. The volume of the nitric oxide so measured is exactly equal to that of the nitrogen as nitrates and nitrites contained in one litre of the water.

2455. Apparatus for the Analysis of Gases.

E. Frankland, F.R.S.

Several of the mechanical arrangements of this apparatus were first employed in an instrument invented by Messrs. Regnault and Reiset, but the principles involved in the determination of the gaseous volumes are different in the two instruments.

The apparatus, which is represented by the accompanying figure, consists of the tripod A furnished with the usual levelling screws, and carrying the vertical pillar B, B, to which is attached, on the one side, the movable mercury trough C, of gutta percha, with its rack and pinion *a*, *a*, and on the other, the glass cylinder D, D, with its contents. This cylinder is 36 inches long and 3 inches in diameter, its lower extremity is cemented into an iron collar, *c*, the under surface of which can be screwed perfectly water-tight upon the bracket-plate, *d*, by the interposition of a vulcanised caoutchouc ring. The circular iron plate *d* is perforated with two large apertures for the passage of the tubes E and F, besides a smaller one into which the brass cock *b* is screwed. E is a glass tube of uniform bore, and about 18 mm. internal diameter, and marked with 10 divisions equidistant from each other. It serves to contain the gas during measurement. Its upper extremity terminates in the capillary tube *e*, which carries a glass stop-cock, and is cemented into the steel cap *f* in such a way as to exclude any air space. For the passage of the electric spark, two platinum wires are fused into E at *g* At its lower extremity the tube E, after passing water-tight through a caoutchouc cork in the plate *d*, is connected with the junction piece *h*.

F is a second glass tube only 5 mm. internal diameter, graduated with a millimetre scale throughout its entire length, and reaching to a height of about 8 inches above the glass cylinder. It is furnished at top with a small funnel, *i*, into the neck of which a glass stopper, about 2 mm. in diameter is carefully ground. In this tube the pressure of the gas in E is measured. Like E, it also passes water-tight through the plate *d*, and is connected with the junction piece *h*, which is furnished with a stop-cock, and is continued to the floor, where it is connected by a long caoutchouc tube with the glass mercury reservoir G. The caoutchouc tube is 3 mm. internal diameter, and is strengthened by a jacket of tape to enable it to withstand the pressure of mercury. The reservoir G can be raised or lowered by the cord and pulley *k*, *l*. H is an absorption tube, in which the gases are brought into contact with various liquid or solid re-agents. It is supported on the clamp *o*, and connected with the capillary tube *e*, by the cap and junction clamp *p*.

The tubes E, F, are held firmly in position by the clamp *m*, which is screwed to the under side of the plate *d*.

Before using the apparatus, the cylinder D, D is filled with water through the cock *b*, and a slow stream is afterwards established through the syphon *n*, one leg of which encloses the upper part of the tube F. The internal walls of the tubes E and F are, once for all, moistened with distilled water by the introduction of a few drops into each, through the stop-cock on *e* and the stoppered funnel *i*. The reservoir, previously filled with mercury, is now placed in communication with the tubes E and F, and is raised until the mercury flows from the cock on *e*, which is then shut, and rises into the cup *i*, the stopper of which is then firmly closed. The absorption tube I, being now filled with quicksilver, and attached to *e* by the screw clamp *p*, the instrument is ready for use.

With a proper supply of water the temperature of the gas remains constant during the entire analysis, and therefore no correction on that score has to be made. The atmospheric pressure being altogether excluded from exercising any influence upon the volumes or pressures, no barometrical observations are requisite; and as the tension of aqueous vapour in E is exactly balanced by that in F, the instrument is in this respect self correcting.

The readings of pressures in this instrument give, without any calculation or correction, the true volumes of the gases, and as the manipulations are very simple, the analysis of even a complex gaseous mixture is made very rapidly. Thus the determination of the separate constituents of a mixture of carbonic anhydride, oxygen, hydrogen, carbonic oxide, marsh gas, and nitrogen can be made in about two hours.

2456a. Apparatus for Analysis of Gases. Modification of that described by Frankland and Ward. For full description see Journ. of Chem. Soc. 1869 [2], vii., 313. *Prof. H. McLeod.*

2456n. Doyèré's Apparatus for Gas Analysis.
Golaz, 24 *Rue des Fosses, St. Jacques, Paris.*

This apparatus consists of a vessel for water and mercury, a telescope, a sheet of plate glass with levelling screws, a transfusing pipe, a detonating eudiometer, and a mercury cistern which is used for the transfusing of the gas.

The vessel for water and mercury is formed of four plates of glass set in a brass frame and resting on a cast-iron slab. Through this latter is an aperture leading to a cistern which projects beyond the vessel, and rises five centimeters above the slab. The latter rests on four feet and stands on a plate levelled by screws. The mercury is poured in by the exterior aperture of the cistern until it has risen one centimeter from the bottom of the vessel; the vessel is then filled with water from above, up to ¾ of its height. The mercury bearing the mass of water rises about 1½ centimeters through the exterior aperture of the cistern, and the levels of the two liquids are established permanently. The graduated tube is put in its place, by making its lower aperture rest in a small iron spoon filled with mercury. By this arrangement the spoon and the tube can traverse the whole mass of water and reach the mercury in the basin, without any of the water penetrating into the interior of the tube. The tube is held by brass pincers, which allow of the reading being made along the whole length of the tube, and consequently of the measurement of even the very smallest volume of gas. The pincers are supported by a rod clamped to a gallows which can be moved vertically by a rack and pinion outside of the vessel. The tube can thus be adjusted to any required height.

The stand of the telescope is formed of two tubes sliding one within the other, with a rack and pinion; at the top of this sliding tube is fixed horizontally a telescope with a micrometer eyepiece. This micrometer allows of the fractions of divisions being measured with great precision. The stand of the telescope is fixed to a tripod furnished with levelling screws. In order to increase the precision of the readings of the instrument and to be able in various cases to advance or draw back the eye-glass in the same optical axis, it rests upon a glass plate mounted in a narrow-brimmed basin provided with wedging screws. The regulator is formed of a glass cylinder, from whose lower extremity issues a tube of small diameter which is bent upwards and rises by the side of the cylinder, is bent at the top, descends paralled to itself, bends once more, and finally ends in a glass reservoir, open at the top.

This tube is fixed to a strip of plate glass on which is engraved an arbitrary scale to serve as a datum for the air-bubble in the tube. The apparatus is clamped to the brass frame at the top of the water vessel, in which it hangs vertically. By its means all calculations of the corrections for temperature, barometric pressure, and the tension of the aqueous vapour, are avoided.

The detonator is a mercurial eudiometer constructed like those usually employed in chemistry.

The transfuser or gas pipette is made of two glass bulbs connected together by a bent tube ; one of these bulbs is surmounted by a tube which is bent at an angle of about 35°. It is by this tube that the aspiration or compression is effected by means of the mouth. The other "bulb" is surmounted by a capillary tube, which rises vertically, is bent horizontally, then descends vertically, is bent once more, and rises again parallel to the descending tube. Its extremity is drawn out to a point. It is with this branch that the gases are exhausted from or forced into the tube in which the measurements are taken in the water-vessel. The whole instrument is mounted on a wooden stand. The cistern for the manipulation is like that on which is placed the water-vessel, but it differs inasmuch as the rim of the surface is lower.

For complete details of experiments see "Les Annales de Physique et de Chimie," vol. XXVIII., third series, 1850.

2456o. Doyèré's Pipette for Gas Analysis Apparatus.
Golaz, 24 Rue des Fosses, St. Jacques, Paris.

2456t. Automatic Eudiometer with alarum.
D. Monnier, Geneva.

2456b. Two Bischof's Evaporating Apparatus to use for Frankland's apparatus. One graduated nitric acid tube. Enamel back. *E. Cetti & Co.*

2455a. Frankland's Water Analysis Apparatus.
E. Cetti & Co.

2456b. McLeod's modification of **Frankland's Apparatus** for the **Analysis** of **Gases.** *E. Cetti & Co.*

2456i. Ure's Eudiometer. *E. Cetti & Co.*

2456k. Mitscherlich's Eudiometer. *E. Cetti & Co.*

2534. Apparatus for boiling off the air from sea-water.
Prof. Oscar Jacobsen, Rostock.

2573. Bunsen's Cathetometer. *Julius Schober, Berlin.*

2660. Apparatus for the **determination** of **Water, Carbonic Acid,** &c., principally for elementary organic analysis, made by Dr. Geissler in Bonn.

Dr. Drevermann, Hoerde, Westphalia.

2556. Geissler's Apparatus for determining carbonic acid.

Ch. F. Geissler & Son, Berlin.

2580. Collection of small **Glass Apparatus** for the **Estimation** of **Carbonic Acid.** *Dr. H. Geissler, Bonn.*

2402. Plattner's Diamond Mortar, in steel.
No. 1, with brass capsule.
No. 2, without ,,
No. 3, ,, ,, *A. Herbst, Berlin.*

2403. Freyberg's Diamond Mortar, in steel.
No. 1, with brass capsule.
No. 2, without ,,
No. 3, ,, ,, *A. Herbst, Berlin.*

2574. Habermann's Air-bath. *Julius Schober, Berlin.*

2574a. Water and Air Bath, with regulator.

P. Waage, Professor of Chemistry at the University of Christiania, Norway.

(NOTE.—For reference letters see photograph.)

(A) is a water-bath heated by two Bunsen lamps, a compartment (*b*) in which serves as an air-bath heated by a copper tube (*c*) coiled in the water and opening into the air-bath.

A tube (*d*) keeps the air-bath in communication with the outer air.

The regulator (B) consists of a **U** tube (*e*) half filled with mercury, and the float (*f*) which rising or falling with the surface of the mercury, shuts or opens the glass cock (*h*) by means of the lever (*g*). This movement can be adjusted by the regulating screw (*i*).

(*l*) is the drying tube filled, for instance, with chloro-calcium.

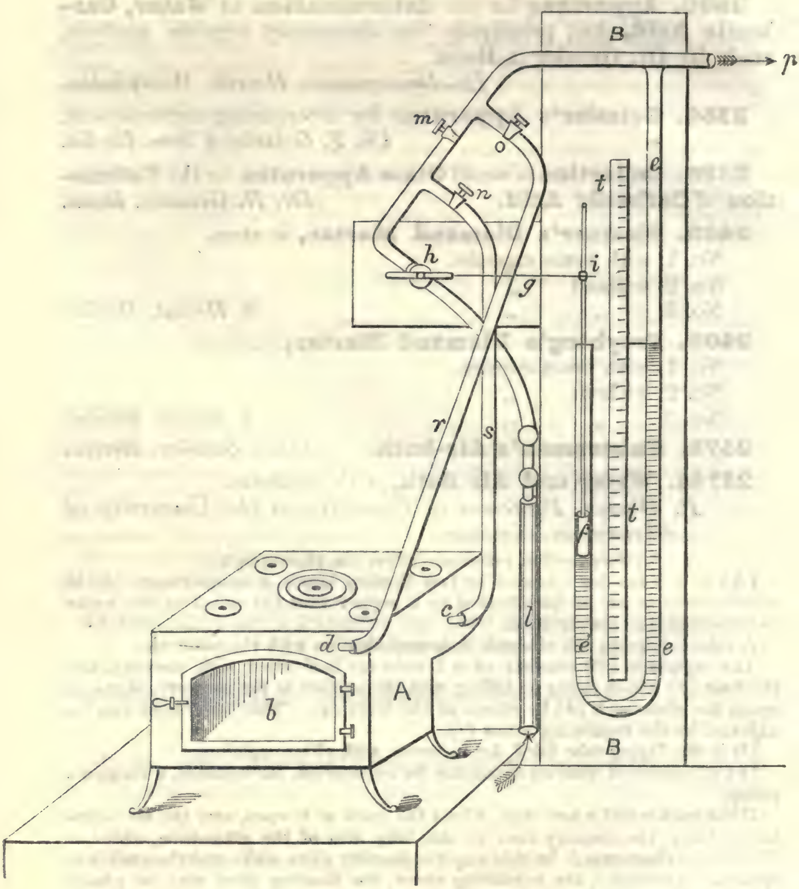
(*p*) is connected with an apparatus for exhaustion, for instance, a Bunsen's pump.

If the cock *o* and *n* are shut, whilst the cock *m* is open, and the air is exhausted at *p*, the mercury rises in the long arm of the glass-tube, whilst it sinks in its short arm. In this way the floating piece sinks and the cock *h* is opened. Through *i*, the regulating screw, the floating piece may be placed higher and lower in such a way that the cock *h* admits the air into the apparatus, in a greater or less state of rarefaction.

If the cock *m* is shut, whilst the cocks *n* and *o* are open, and when these cocks have been connected with *c* and *d*, through the india-rubber tubes *r* and *s*, whilst the other end of the tube *l* ending in the air-bath, is connected with the interior opening of the copper-tube *d*,—then the air that enters through the drying tube by the cock at a given rarefaction, will first go into the copper coil at *c*, and then, having been heated to 100° C., will enter the air-bath to be from thence exhausted by the pump through the cock *o*.

The air-bath can thus be filled with warm dry air at any pressure that may be desired.

Besides, with the object just named, the regulator may also be used under filtration with Bunsen's pump. In this case one of the india-rubber tubes, for instance *s*, is brought into connection with the filtering apparatus, the



cock *o* is opened, but *n* and *m* are shut, and the floating piece is, by the help of the millimeter-scale *t,* placed so as to give the desired rarefaction.

The regulator may also be employed with a distilling apparatus in connection with the rarefied air. In this case, one india-rubber tube is put in connection with one end of the air-tight apparatus of distillation, and the other india-rubber tube is put in connection with its other end.

2578. Collection of Burettes and Burette Stands.

Dr. H. Geissler, Bonn.

2579. Collection of Pipettes, with stand.

Dr. H. Geissler, Bonn.

2585. Drying Closet, provided with mica-plates, for watching the drying of precipitates obtained in quantitative chemical analysis (*see* Mineralogy). *Max. Raphael, Breslau.*

2586. Mitscherlich's Apparatus for organic analysis by means of mercuric oxide. *Prof. A. Mitscherlich, Münden.*

The apparatus is described in Mitscherlich's paper entitled "Elementar analyse vermittelst Quecksilber oxyd," published by E. S. Mittler and Son, Berlin, copies of which accompany the apparatus.

2587. Mitscherlich's Metal Drying Closet, with accessories. *Prof. A. Mitscherlich, Münden.*

A description of this apparatus will be found in Mitscherlich's papers, entitled "Chemische Abhandlungen," published by E. S. Mittler and Son, Berlin, 1859–65.

2530. Phosphorus Eudiometer.
University of Munich, Prof. von Jolly.

2443. Apparatus for Volumetric Analysis.
James How & Co.

2563. Hofmann's Filtering Stand, the metal rings of which are lined with wooden rings slanting at an angle of 60°.
Julius Schober, Berlin.

2567. Hofmann's Combustion Furnace.
Julius Schober, Berlin.

2568. Bunsen's Combustion Furnace.
Julius Schober, Berlin.

2569. Finkener's Combustion Furnace.
Julius Schober, Berlin.

2456d. Set of **Russell** and **West's Apparatus** for estimating the urea in urine. *E. Cetti & Co.*

2456e. Six **Burettes** and **Scale Pipettes,** with registered enamel back to show up the divisions. *E. Cetti & Co.*

2456g. Nessler's Tubes for **Colour Test.** *E. Cetti & Co.*

2592. Self-filling Burette, used for oxidizable liquids, together with filling bottle, wash-bottle, stand, and india-rubber tubes.
Berggewerkschaftskasse, Bochum, Rhenish Prussia.

The working of this burette is described in Fresenius' Zeitschr. f. anal. Chem. XIV., 3 and 4.

IV.—APPARATUS IN GENERAL USE IN LABORATORIES.

2525. Apparatus for **regulating** the **Pressure** of **Gas.**

Prof. A. Crum Brown.

The apparatus consists of a gasometer, the pressure of the gas in which depends upon the weight of the inverted vessel and that of the counterpoises. The peculiarity of the arrangement lies in the mode in which the gas is introduced into the gasometer. The gas is led from the main or meter to a fixed vertical tube, and thence by a short piece of india-rubber tube to a metal tube fixed to one of the counterpoising weights, and from that tube to the gasometer. When the pressure in the main increases the vessel rises, and the counterpoise falls; the short india-rubber tube is thus bent, and the entrance of gas into the gasometer hindered. This short india rubber tube is thus a self-acting valve, always admitting exactly the same quantity of gas as is drawn off from the gasometer, and as the motion of the gasometer is very small, the pressure is practically constant.

2524a. Oxygen Generator. *John Craig.*

The gas (generated from chlorate of potash and manganese, in equal quantities) passes from the retort C to the bottom of the gas holder B (which is filled with water) by the tube F. The water is displaced through the tube H into the reservoir A until the pressure has been reached for which the lever Q has been loaded. When that point has been reached, the pressure acting on the bellows K raises the lever Q, and so diminishing the source of heat; the other end of the lever regulating the air to the amount of gas admitted to the Bunsen burner. (By changing the fulcrum of the lever to U the sliding tube is reversed in its action, and adapted for diminishing the flame of a spirit or other lamp where gas is not available.) When the pressure is again reduced below the required limit, the lever, falls, opens the stop-cock O, and more gas is generated. The object of the second retort is that the one may be re-charged while the other is in use, thereby securing continuous action. A convenient working pressure is found with 3 inches of water in the reservoir. The regulator J controls the pressure of gas through the exit pipe I, fulfilling the same office as the regulator in the hydrogen generator. By this means both the production and working pressure of the gas is regulated.

The *advantages* of the combined apparatus are, 1st, a continuous or intermittent supply of oxygen and hydrogen gases may be obtained in any quantity and at any pressure, as the rate of production depends solely on the rate at which the gases are consumed; 2nd, being self-acting, little superintendence is required; 3rd, great economy (as compared with the use of bags), all the gas made being available; 4th, danger from explosion is reduced to a minimum (*a.*) from the small quantity of gas in stock, and (*b.*) undue tampering with the levers would only result in bursting the cloth bellows of the regulator.

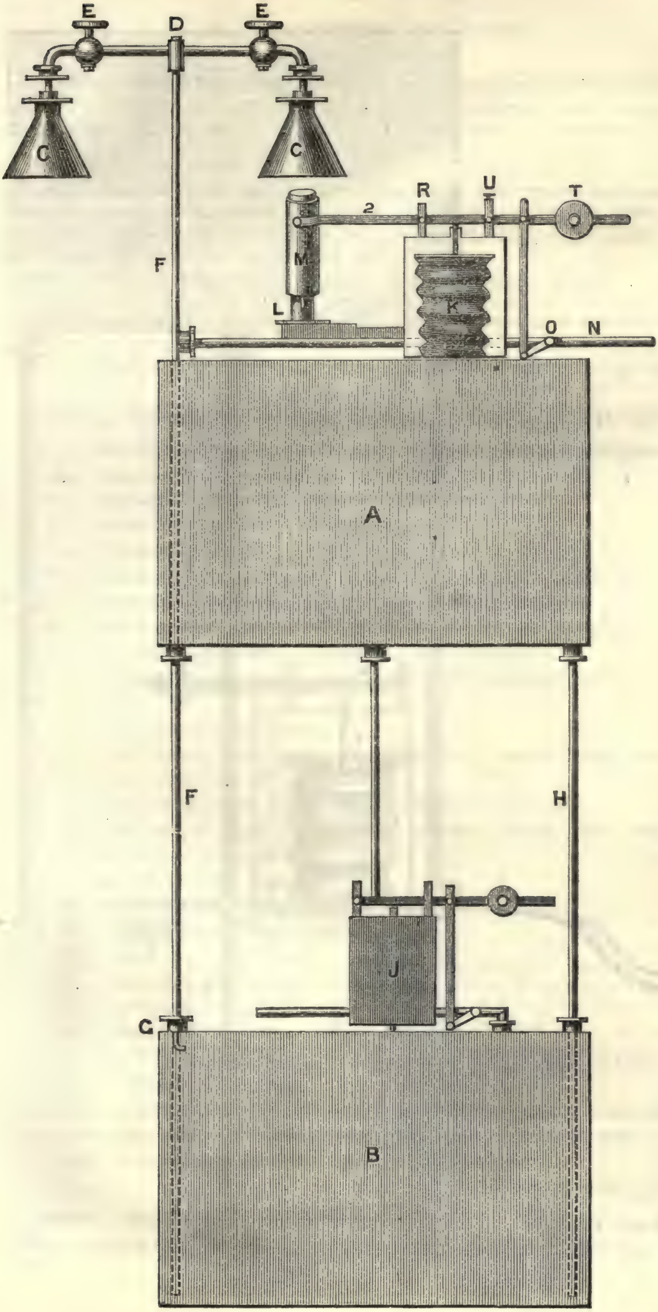
At G there is a small valve, which remains shut until the heat is withdrawn from the retort; when, to prevent the water rising to fill the partial vacuum from condensation in the retort, communication is at once established by the valve rising and allowing gas to restore the equilibrium.

The apparatus is suitable for lighthouses, signal lights, ships' lights, &c.

The three copper tubes are adopted to the hydrogen generator, the three brass tubes to oxygen.

2524b. Hydrogen Generator. *John Craig*

To generate the gas pieces of zinc are placed in the lower vessel at E. Dilute acid, added to the upper vessel A, comes in contact with the zinc


E
D
E
C
C
R
U
T
2
M
F
L
K
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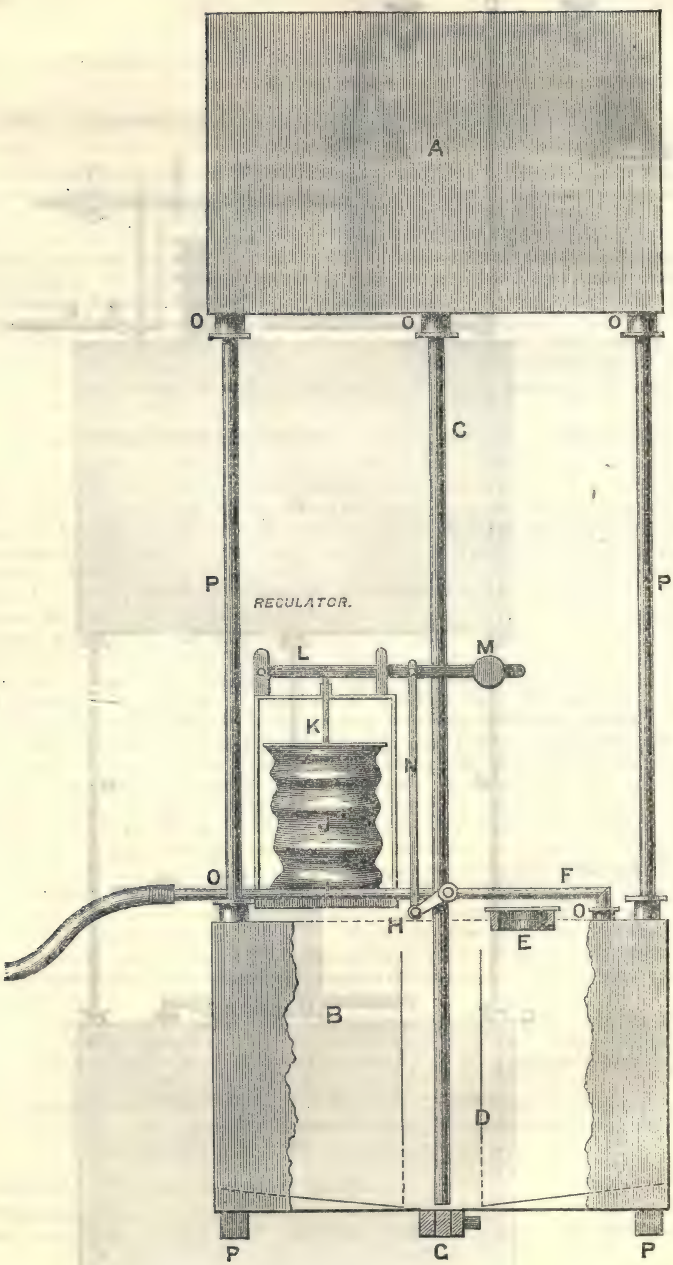

A
O
O
O
C
P
P
REGULATOR.
L
M
K
N
J
O
F
H
E
O
B
D
P
C
P

through the pipe C, when hydrogen is at once produced. If no gas is taken away the acid liquid is all forced back into the upper vessel, when the production ceases. When gas is taken away at F the lessened resistance allows as much acid to return to the lower vessel as will supply the demand. The fountain head pressure is determined by the distance between the upper and lower vessels, combined with the quantity of liquid in the upper chamber. The burning pressure is determined by the weight M on the lever L, which when once fixed remains constant and is independent of changes produced by the rising and falling of the liquid in the pipe C.

D is a perforated fence to prevent the zinc closing the bottom of tube C F the tube through which the gas passes to the burner. G the stop-cock to withdraw spent acid. H the stop-cock crank, at an angle of 45° when open. I where the gas enters the bellows of the regulator. J bellows. K stud. L lever. M weight. N connecting rod. O screw couplings. P supports.

2572. Collection of Gas Lamps of novel Construction.

(1.) Gas lamp provided with one regulator for air and gas.
(2.) Gas lamp with separate regulator for air.
(3.) Gas lamp with star support and chimney.
(4.) Bunsen's gas lamp, single burner.
(5.) Bunsen's gas lamp, with regulation for air supply.
(6.) Bunsen's gas lamp, with star support and chimney.
(7.) Bunsen's gas lamp, consisting of 3 burners.
(8.) Bunsen's gas lamp, with regulation for air supply.
(9.) Bunsen's gas lamp, consisting of 6 burners.
(10.) Bunsen's gas lamp, provided with one regulator for both gas and air.
(11.) Hofmann's gas lamp.
(12.) Hofmann's gas lamp, provided with an air regulator, star support, and chimney.
(13.) Hofmann's gas lamp, with a bent burner tube.
(14.) Hofmann's gas lamp, with a bent burner tube, and provided with an air regulator.
(15.) Griffin's rose burner.
(16.) Griffin's small gas lamp.
(17.) Griffin's large gas lamp.
(18.) Microchemical lamp.
(19.) Iserlohn gas lamp, small size.
(20.) Iserlohn gas lamp, middle size.
(21.) Iserlohn gas lamp, larger size.
(22.) A fusion gas lamp, consisting of 11 single burners, and fixed on a stand.
(23.) A gas lamp, consisting of 3 burners, each possessing a separate regulator for a simultaneous supply of air and gas.
(24.) A gas lamp, containing 4 burner tubes.

Julius Schober, Berlin.

2446. One-inch Solid Flame Bunsen Burner and two Perforated Caps, the fine one for ordinary use, and the coarse one to exhibit the green beads above each perforation more distinctly. *John Wallace, Messrs. Tangye Bros., and Rake.*

2447. Two-inch Solid Flame Bunsen Burner, with a piece of sheet platinum suspended across the top of the cap in order to show by its incandescence that the flame is solid to the centre. These burners will burn safely a mixture of $4\frac{6}{10}$ volume of air per volume of gas.

John Wallace, Messrs. Tangye Bros., and Rake.

By the addition of a perforated metallic cap, adjustable to various heights on the burner tube, the ordinary Bunsen burner may be increased to 2″ or more in diameter, while at the same time the combustion is greatly improved and the disposition to light within prevented. In the ordinary half-inch burner one and a quarter volumes is about the maximum quantity of air which may safely be mixed with the gas previous to combustion without running the risk of lighting within. In the new burner 4·6 volumes of air may be safely mixed previous to combustion.

By raising or lowering the cap the proportion of air drawn in at the base of the burner may be varied at pleasure, and when the maximum amount of air is used a flame of marvellous beauty is obtained, which differs in many respects from the ordinary atmospheric flame. The hollow conical space within the flame entirely disappears, leaving a perfectly solid flame, while above each perforation of the cap is seen an intensely brilliant green bead, indicating the beginning of combustion. These beads are hollow, and are filled with the mixture of air and gas passing through the cap. Their colour is entirely on the surface, and they fade and merge into each other on a slight interruption of the air supply below. They cannot be regarded as separate flames, as they have no separate air supply, and their colour is the same whether the cap be of copper or iron.

As the pre-admixture of air increases the flame becomes smaller and more intense; the heat is produced in less space, and is thus better adapted for boiling liquids or heating metals. The absence of the hollow cone points to some interesting peculiarities in the flame. In a flame 3″ diameter from a 2″ burner the green beads (those most sensitive indices of any change in the physical condition of the flame) are of the same size and colour from the outer edge to the middle of the cap. They are all filled with the same mixture of gas and air, and their uniformity can only be accounted for by supposing that each one gets its complement of air with equal facility.

About $6\frac{1}{3}$ volumes of air are necessary to consume London gas, and one half of this amount will produce a carbonic oxide flame. But when $4\frac{6}{10}$ volumes are mixed previous to combusion there is more than the amount required to produce a carbonic oxide flame; this fact, together with its uniform appearance, offers grounds for supposing that the flame is a carbonic acid one, and that the oxygen which combines during combustion reaches every part of it with equal facility. The penetrating power of the oxygen is here so remarkable that the question naturally arises, "does it drag its associated nitrogen with "it into the heart of the flame, parting only at the time of combination, or, "does dissociation take place before the oxygen combines with the carbon "and hydrogen of the gas?"

2447a. Wallace Bunsen Burner, Tangent pattern.

John Wallace, Messrs. Tangye Bros., & Rake.

This apparatus consists of a hemispherical chamber or vessel into which a jet of coal gas is discharged at a tangent carrying with it a certain proportion of air which by eddying round within the chamber is ultimately mixed with the gas. The mixture escapes by a short tube in the middle of the chamber, and burns with an amber flame containing a brilliant green cone within it. This cone is a hollow space in the flame in which the head of a lucifer match, if dexterously inserted, will not ignite. The flame above will readily melt gold, silver or copper, indicating a temperature equal to about 3000° Fahr.

2740. Chemical Apparatus, Photometrical and **Gasometrical Apparatus, Lamps, &c.,** invented by Professor Bunsen, of Heidelberg, and described by him in his "Gasometrical Methods," and other publications. *C. Desaga, Heidelberg.*

Spirometer.
Goniometer.
Galvanic battery, consisting of four elements.
Table blowpipe lamp, with 2 jets.
A 6-Bunsen burner blowpipe table lamp.
An 18-Bunsen burner blowpipe table lamp.
Oxy-hydrogen blowpipe.
Iron tripods, four different sizes.
Small tripods for fixing on lamps.
Small tripods for spreading out the flame.
Electrometer.
Bunsen's water vacuum pump.
Air-pump plate.
Spark-producer.
24 compression clamps of different sizes.
Potash apparatus.
4 supports for flasks, &c.
Apparatus for cooling (condenser).
Bunsen gas burners, 18 different sorts.
Babo's lamps, five different kinds.
Breitenlohner's lamp.
Lamps with double and treble air draught.
A 7-Bunsen burner lamp.
Sevenfold lamp.
Gas blowpipe, provided with stopcock.
Gas blowpipe, mounted.
Furnace, containing 25 burners.
Circular gas furnace, three different forms.
Absorptiometer.
Diffusion apparatus.
Dividing machine for glass gas apparatus.
Cathetometer.
Oxy-hydrogen generating apparatus.
Mercury trough.

System of convergent lines, etched on glass, for making divisions.

Hydrogen generating apparatus.

Apparatus for measuring the rapidity with which gases issue through a narrow aperture.

Spectroscope.

Spectroscope, provided with micrometer movement for the two telescopic tubes, an eccentric movement for the adjustment of the observation telescope, comparison prisms, cross-thread, &c.

Pocket spectroscope.

Universal clamp.

Stand for holding flasks, &c.

Stand for holding Geissler's tubes.

Stand for holding carbon points.

2 stands provided with adjusting screws.

2 stands provided with three legs.

3 holders for burettes.

6 rings of different sizes.

6 filtering rings of different sizes.

2 forks.

7 clamps.

Photometer.

Gas-clock.

Test-tube holder.

2 water baths, 2 sizes.

Apparatus for regulating the level of water.

Bunsen's gas regulator.

Drying apparatus.

Apparatus for showing the reversal of the sodium spectrum.

Several cases containing chemical substances for practising spectroscopic analysis.

Chimneys for the various lamps, 15 different sizes.

2574b. Doberawer's or Philosopher's Lamp.

Parkinson & Frodsham.

This lamp when charged with dilute sulphuric acid is self-igniting; it suffices to raise the arms of the small figure, and the spongy platinum then brought into view, becomes incandescent. The explanation of this is that the hydrogen generated in the body of the lamp, which contains zinc, is drawn into such close contact with the oxygen of the air, by reason of the extreme fineness of the spaces between the particles of the platinum, that the two gases combine chemically, or in other words burn, whereby sufficient heat is generated to raise the temperature of the platinum to a red heat, sufficient to ignite paper, &c.

2572a. Heating Apparatus for Laboratories.

M. Wiesnegg, Paris.

1. (?) Arched Bunsen burner.
2. Plain Bunsen burner, with support.

3. Bunsen burner of 8 millimetres.
4. Three tye-pieces for gas burners.
5. Treble Bunsen burner.
6. Wiesnegg burner, with stand.
7. Berzélius burner, for gas and air.
8. Stove "à couronne," No. 1.
9. Do. do. No. 2.
12. Laboratory blow-pipe, for petroleum.
13. Bellows, with handle and treddle.
14. Leclerc oven.
15. Cloës universal stand, with hook.
16. A hand blow-pipe.
17. Complete Schlœsing blow-pipe.
18. Two Schlœsing ovens, No. 1.
19. One do. No. 2.
20. Tube oven, and model of oven for melting platinum.
21. Perrot apparatus, No. 1.
22. Clothing framework of Perrot apparatus.
23. Perrot apparatus, No. 2.
24. Perrot coppel, No. 5, with treble clothing.
25. Oxygen retort.
26. Complete oxygen bladder.
27. Two Perrot cocks and light strikers combined.
28. Cloës "étuve."
29. Ranvier "étuve."
30. Wiesnegg "étuve."
31. Fremy "étuve."
32. Two gridirons for analysis (18 and 14 burners).
33. Stove "à couronne," No. 1, for petroleum.
34. Stove "à couronne," No. 2, for petroleum.
35. Gas stove for incineration, with two jackets.
36. ? Candelabra for lecture theatre.
37. Complete still.
38. Perrot burner, No. (?), for petroleum.
39. 150 burners of various sorts, copper.
40. Pressure and gas caoutchouc.
41. Twelve Wiesnegg briquettes, No. 2, and 8 quarter briquettes.
42. Twenty Wiesnegg briquettes, No. 1 (?), and 8 quarter briquettes.
43. Eight Perrot plots.
44. Twelve manometer glasses.
45. A small ingot mould and a large one.
46. Two charcoal and crucible tongs.

2524. Laboratory Forge, with double draught, fitted with a cerfeu for the fusion of metals.

With this forge the pressure can be increased by reducing the quantity of air when soldering is required, either with gas, or with Sainte Claire Deville's forge lamp, or with Schlösing's blow-pipe.

2560. Apparatus for producing a **Blast of Air** by the fall of water. (Catalonian "Trompa".) *Dr. Otto Bach, Leipzig.*

Founded on the principle of the hydraulic ram, with the sole difference that the caoutchouc bag (or conduit) takes the place of the valve. It is especially fitted for the use of glassblowers on account of its quiet and perfectly uniform blast of air, and by the introduction of Bunsen valves (ventiles) it can be adapted for all the purposes of a water air-pump, as it then corresponds to the "Pulsirpumpe" designed by Faguo in Moscow, and described in the report of the German Chemical Society, 5.328.

2598. Blowing Apparatus for working a blow-pipe.
C. Osterland, Freiberg, Saxony.

This blowing apparatus has two wind-chambers, whereby a perfectly regular stream of air may be obtained, even without any previous practice. It has a movable jet, constructed by the exhibitor, with an air-tight ball-and-socket movement. It may be screwed fast to a table, and will continue blowing for nearly a minute before the air-chambers get exhausted. It can also be worked by the foot, so as to leave both hands free. The stream of air can be regulated by a tap, in order to suit every requirement.

2570. Hofmann's Table Blowpipe Lamp.
Julius Schober, Berlin.

2571. Bunsen's Table Blowpipe Lamp.
Julius Schober, Berlin.

2571a. Apparatus for developing the new system of **Blowpipe Chemistry,** called "pyrology," a "spectrum lorgnette," pyrological candles, and other novelties; together with some of the results, as the sublimate of gold on aluminium plate, &c.
Major W. A. Ross.

2561. Small Copper Steam Generator.
Julius Schober, Berlin.

2596. High-pressure Steam-boiler, together with a distilling and condensing apparatus, as well as a drying closet, capable of being heated by steam. *E. A. Lentz, Berlin.*

The apparatus is heated by 10 Bunsen burners; when steam is once got up only half the number is required to keep it up; the other half may then be turned off.

The three openings in the apparatus for evaporations are separated from the steam chamber by copper casings, and the steam is let into the latter when required for use by means of small valves. It is thus possible to maintain a certain pressure of steam in the boiler, which is of especial importance when steam has to be used for distillations and for conducting to a distance, as, for instance, in the heating of distant drying-closets.

2596a. Apparatus for Drying in Vacuo.
Prof. Markovnikoff, Professor of Chemistry at the University of Moscow.

2596b. Laboratory Furnace; magnesia.
Prof. Schloesing, Conservatoire des Arts et Métiers, Paris.

2596c. Laboratory Furnace; brick.
Prof. Schloesing, Conservatoire des Arts et Métiers, Paris.

2596d. Distilling Apparatus, for laboratory.
Prof. Schloesing, Conservatoire des Arts et Métiers, Paris.

2456b. Apparatus for simultaneous production of hydrogen, carbonic acid, and sulphuretted hydrogen.

P. Waage, Professor of Chemistry and Director of the Chemical Laboratory at the Royal University of Christiania, Norway.

The apparatus consists of a reservoir for hydrochloric acid of 10–15 per cent. strength. At the bottom of this reservoir are three apertures through which it is connected in the usual manner by glass tubes and stopcocks with three cylindrical jars, one filled with zinc, the second with marble, and the third with sulphide of iron. Beneath each of these, and communicating with the sewers, is another reservoir into which the solutions of chlorides are gathered. The three gases generated are conducted through wash bottles furnished with stopcocks of glass; when these are turned off the several gases and the solutions of chlorides will pass through the lower reservoirs into the sewers.

The apparatus once fitted up is always ready for use, and all superfluous gas is completely led away without producing any smell in the room where the apparatus is fixed.

2523. Stand used in chemistry for the fusion of metals by means of a gas apparatus.

2593. Stand provided with pincers and air-bath.
Ball, Freiburg, Baden.

2595. Heat Regulator. *C. Kramer, Freiburg, Baden.*

2550. Frerich's filtering Apparatus, made of platinum.
F. Sartorius, Göttingen.

2551. Frerich's filtering Apparatus, made of gutta percha. *F. Sartorius, Göttingen.*

2552. Frerich's filtering Apparatus, made of porcelain.
F. Sartorius, Göttingen.

2553. Frerich's Apparatus, for determining specific gravities in scientific investigations. *F. Sartorius, Göttingen.*

2456c. Water Quick Filter Pump for use with a fall of 40 feet. *E. Cetti & Co.*

2576. Water Vacuum Pump, constructed for a fall of water of at least 20 feet. *F. A. Wolff & Sons, Heilbronn and Vienna.*

This pump is of simple construction and great solidity. Any desired vacuum may be obtained by making use of a regulator.

2663. "Water Jet" Pneumatic Pump, for laboratories, &c.; designed by Professors Arzberger and Zulkowsky, and constructed by P. Böhme, Mechanician, Brünn.

Prof. Fred. Arzberger and Chas. Zulkowsky, of the Polytechnic Institute, Brünn, Austria.

The effect of this pump is based on the injection principle; it requires for working it a water supply conveyed by high pressure, but no fall below;

hence the difficulties are avoided which frequently impeded the employment of earlier designed pneumatic water pumps. The rarefaction of air produced by it, which is entirely dependent on the amount of pressure caused by the influx of the water, may be increased with a single pressure of about one atmosphere to a degree of tension equal to that of steam.

Described in Liebig's Annalen der Chemie, Vol. 176.

2558. Apparatus for producing a **Vacuum** for purposes of **Crystallization** and **Filtration.** *Hermann Fischer, Hanover.*

2559. Spring-Vacuometer, belonging to the above apparatus. *Hermann Fischer, Hanover.*

The apparatus, which is principally intended to replace Bunsen's filtering pumps, is constructed on the principle of the injection pump, producing a vacuum by means of a powerful jet of water. The little vacuometer contains a Schinz' tube. If the tube, marked water, be joined to the water supply pipe by means of an india-rubber tube, and the tube which in the drawing is not shown at all be joined to the waste pipe, and connexion be made with the vessel which is to be exhausted, a corresponding vacuum is readily produced. With a fall of water of 11 m. a vacuum will be formed which at most will only fall short by one cm. from the absolute barometric height. If the water used be allowed to flow freely into a vessel, the level of the water must be deducted from the height of the water column above the apparatus. The vacuometer is made small in order to render the apparatus more handy. The apparatus may also be used without the vacuometer.

The advantages of the whole apparatus are as follows :—(1.) It is very handy; (2.) It may be used on every work-bench which is provided with a supply of water ; and lastly (3.) It is very cheap.

2554. A. Müller's Subsiding and Washing Apparatus, provided with a set of sieves and a second indicator, for agricultural analysis. *Franz Schmidt and Haensch, Berlin.*

This apparatus is accompanied by a pamphlet descriptive of its application.

2565. Wolf's improved **set of Sieves** with **Brushes.** *Franz Hugershoff, Leipzig.*

1959. Two Hydrostatic Rotary Engines or Precipitating Machines, with table to which eccentric motion is conveyed. The machines were invented by the exhibitor for the purpose of facilitating the solution, aggregation, or precipitation of chemical compounds, which they do as effectually in half an hour as if the solutions were allowed to stand for 24 hours (tested by quantitative experiments). The table is open in the centre, so that a beaker or flask may be heated by a Bunsen burner, and it is furnished with double-sliding clamps so as to securely hold the vessel in its place.

A, engine intended for delicate quantitative experiments.

B, engine for ordinary purposes.

Joseph William Thomas, Cardiff.

2589. Mica-plates used for effecting fusions and for evaporations (*see* Mineralogy). *Max. Raphael, Breslau.*

Mica is not affected by most acids. This material may also be employed as a cheap substitute for platinum in many chemical operations.

2590. Mica Powder, for use in filtrations. *Max. Raphael, Breslau.*

2591. Mica-spectacles, for use in laboratories, to protect the eyes in all operations when dangers from spitting or from explosions have to be guarded against. *Max. Raphael, Breslau.*

2594. Ozone generating Tube, provided with drying apparatus. *C. Kramer, Freiburg, Baden.*

2547a. Fairley's simple form of Ozone Generator in Glass. *Harvey, Reynolds, and Co.*

2577. Hydrofluoric Acid Apparatus, in lead. *F. A. Wolff & Sons, Heilbronn and Vienna.*

For the use of public laboratories.

2557. Collection of Glass Stop-cocks of various sizes. *Ch. F. Geissler & Son, Berlin.*

2581. Collection of **Glass Stop-cocks.** *Dr. H. Geissler, Bonn.*

2602. A. Mitscherlich's Apparatus for the continuous evolution of chlorine gas, together with a water bath having a constant water level. *Prof. A. Mitscherlich, Münden.*

This apparatus is described in A. Mitscherlich's chemical publications, part 2, p. 6.

1377c. Apparatus for the **Production** of **Hydrogen Gas.** *Alvergniat Frères, Paris.*

V. MODELS, DIAGRAMS, APPARATUS, AND CHEMICALS EMPLOYED IN OR RESULTING FROM CHEMICAL MANUFACTURES; ANALYTICAL APPARATUS USED IN MANUFACTORIES.

2566b. Patent Platinum Apparatus. *Johnson, Matthey, and Co.*

Newest form for the concentration of sulphuric acid, securing great strength, productive power, safety and economy in working, and highest degree of purity of acid, with a minimum of platinum :—

Boiler.—By the corrugated form of bottom (Prentice's patent) the greatest possible amount of strength, surface, and consequent evaporating power is obtained, and a considerable saving in fuel is effected.

Pans.—By means of these vessels the large and costly leaden tanks for the previous concentration of the chamber acid, which require constant repair and renewal and more or less contaminate the acid, are entirely done away with.

The setting of these boilers and open pans is of the simplest kind ; they are placed upon an iron frame over a straight flue, and they may be multiplied or enlarged to any desired capacity of production, without sacrifice of existing plant.

Cooler.—An improved economical and convenient form, securing great cooling power with a minimum of water and space.

The total cost of such apparatus composed entirely of platinum, and, therefore, always of great intrinsic value in comparison with the first outlay, is less than that of any other form yet introduced.

Briefly, the chief advantages of this construction are :—

Great economy in first outlay and daily expense of working.

Great intrinsic value in a realisable form in proportion to the cost.

Purity of acid, and freedom from danger.

2689. Common Salt. From the salt works of Northwich, Cheshire, used in the manufacture of salt cake or sulphate of soda. *Sullivan & Co.*

2690. Salt Cake, or commercial sulphate of soda, containing about 98 per cent. of real sulphate, made by decomposing common salt with vitriol in an iron pan heated externally. When about three fourths of the decomposition has been effected, the charge is pushed upon the bed of a "muffle" furnace, maintained at a bright red heat till the decomposition is completed. The gaseous hydrochloric acid evolved during the process is conducted away through pipes or flues to condensing towers, where, being absorbed by water, it assumes the form of liquid acid. *Sullivan & Co.*

2691. Limestone, or native carbonate of lime from Derbyshire, used in combination with slack or small coal for converting salt cake or sulphate of soda into carbonate of soda. *Sullivan & Co.*

2692. Slack, or small coal from the Lancashire coalfield, used in combination with limestone for converting salt cake or sulphate of soda into carbonate of soda. *Sullivan & Co.*

2693. Black Ash, or ball soda, containing about 24 per cent. of soda, produced by fluxing together in a suitable furnace a mixture of salt cake or sulphate of soda, limestone, and slack, by which means the sulphate of soda is converted into carbonate of soda, the carbonate of lime of the limestone into calcium sulphide, and the slack into coke. *Sullivan & Co*

2694. Vat Liquor. A saturated solution of soda produced by lixiviating "black ash" or "ball soda" with warm water in iron tanks or vats; when the solution is saturated it is run off into iron pans to be boiled down, the calcium sulphide and unburnt coke of the "black ash" being left behind in the vat as "tank" or "vat waste." *Sullivan & Co.*

2695. Salts, or crude carbonate of soda, obtained by boiling down "vat liquors" in iron pans, heated either externally or by passing the flame over the surface of the liquor in the pan. *Sullivan & Co.*

2696. Soda Ash, or finished carbonate of soda of commerce, containing 58·5 per cent. of real alkali, produced by gradually heating to redness in a reverberatory furnace "salts" or crude carbonate of soda. *Sullivan & Co.*

2697. Salt, as used in the "Hargreaves" process. The salt is placed in a moist state on drying floors, and when dried into hard flat pieces is broken by machinery. *Sullivan & Co.*

2698. Salt Cake, or sulphate of soda containing 99 per cent. of real sulphate, made without the use of sulphuric acid by the "Hargreaves" direct action process. Salt maintained at a red heat in iron cylinders is exposed to the direct action of sulphurous acid, air, and steam. The hydrochloric acid from the salt is condensed as in the ordinary process. *Sullivan & Co.*

2469. Drawings (4) of Hargreaves and Robinson's Sulphate of Soda Apparatus. 1. General plan. 2. Enlarged sectional plan. 3. Transverse sectional plan. 4. Condensing apparatus. *J. Hargreaves & T. Robinson.*

2470. Samples of: A. Salt prepared for the converting cylinders above. B. Sulphate of soda. C. Hydrochloric acid. *J. Hargreaves & T. Robinson.*

Sulphurous acid, steam and air, are made to react upon salt directly, producing sulphate of soda and hydrochloric acid, without the preliminary manufacture of sulphuric acid. The salt is placed in the iron cylinders, and the mixture of sulphurous acid, air, and steam passed through it. The evolved hydrochloric acid is taken out at the bottom of the cylinders, and conveyed to the condensers.

2738a. Drawing of Root's Patent (special) Blower for Hargreaves' process in the manufacture of sulphates. *Thwaites & Carbutt.*

2738b. Model of Root's Patent Pressure Blower.
Thwaites & Carbutt.

2448. Models of Hydrochloric Acid Condensing Towers, as erected at Messrs. Hutchinson's Alkali Works at Widnes. *Prof. Roscoe, F.R.S.*

2449. Model of Salt-Cake Furnace, with open roaster.
Prof. Roscoe, F.R.S.

2450. Model of Finishing (Alkali) Furnace.
Prof. Roscoe, F.R.S.

2451. Model of "Weldon" plant for the regeneration of Black Oxide of Manganese in the Manufacture of Chlorine.
Prof. Roscoe, F.R.S.

2717. Soda Crystals, or **Washing Soda.** To obtain these crystals, soda ash is dissolved in hot water, and the clear solution is run into iron vessels, where a large part of the soda crystallizes out. *Gaskell, Deacon, & Co.*

Composition:—

$$Na_2CO_3 + 10\ Aq.$$

2708. Mother Liquor. When the crystallization of the soda is complete, the remaining liquid, or "mother liquor," is run off. This contains nearly all the soluble impurities in the "soda ash."
Gaskell, Deacon, & Co.

2709. Refined Alkali. To obtain this, soda ash is dissolved in hot water, the clear solution is evaporated, when a monohydrated carbonate of soda is precipitated, which is then calcined and ground. *Gaskell, Deacon, & Co.*

2710. Red Liquor. In some cases the vat liquor is not evaporated to dryness, the residual liquor (called, from its colour, "red liquor") containing the greater part of the caustic soda, sodium chloride, sulphate, sulphites, sulphide, and other impurities, is separated, and subsequently treated for the production of caustic soda. *Gaskell, Deacon, & Co.*

2711. Oxidized Red Liquor. The sulphides, sulphites, &c. in the red liquor are wholly or partially oxidized by blowing air through the red liquor in deep iron vessels.
Gaskell, Deacon, & Co.

2712. Causticised Liquor. After oxidation the red liquor is diluted to about 1·080 specific gravity, and rendered caustic by agitation in contact with caustic lime. *Gaskell, Deacon, & Co.*

2713. Cream Caustic. The causticised liquor is concentrated by evaporation until the solution sets hard on cooling, and tests 60 per cent. of alkali. During this concentration some of the sodium sulphate and a little carbonate are precipitated, and are ladled out, and any further oxidation required is effected by the addition of nitrate of soda. *Gaskell, Deacon, & Co.*

2714. White 60 per cent. Caustic Soda. To obtain this the causticised liquor is concentrated until the unevaporated portion fuses, when the iron (which has probably been held in solution by combination with cyanogen), and the greater part of the alumina and silica, are precipitated and allowed to settle; the clear fused caustic soda, containing some sodium sulphate and chloride, is packed in iron drums. *Gaskell, Deacon, & Co.*

2715. White 70 per cent. Caustic. This is obtained in the same manner as white 60 per cent., except that care is taken during the concentration to remove sufficient sodium sulphate and chloride to enable the resultant caustic to be of the required strength. *Gaskell, Deacon, & Co.*

2716. Chloride of Calcium. This is obtained as a bye product from the manufacture of bicarbonate of soda or from the "Weldon" process. The solution of chloride of calcium is purified and settled, and concentrated by evaporation.

Gaskell, Deacon, & Co.

Composition:—

$CaCl_2$.
Aq.

2472. Samples of Bicarbonate of Soda unground; also ground and dressed. *John Hutchinson & Co.*

2471. Samples illustrative of Mond's process for the recovery of sulphur from alkali (vat or tank) waste:

1. Alkali (vat or tank) waste before oxidation.
2. Alkali (vat or tank) waste after oxidation.
3. Sulphur liquor.
4. Precipitated sulphur.
5. Sulphur in bulk.
6. Roll sulphur.

John Hutchinson & Co.

2477. Soda Waste, Alkali Waste, Black Ash Waste, or Tank Waste. Insoluble residue formed in the second or black ash stage of Leblanc's process for obtaining soda from common salt. *John Hutchinson & Co.*

From the appended analysis by Kopp of a sample it will be seen that a large quantity of sulphur is present in the waste. A part of this can be profitably extracted by Mond's and other processes.

Sulphide of sodium	2,880
Carbonate of lime	13,636
Silicate of lime	5,680
Hydrate of lime	8,588
Monosulphide of calcium	22,162
Alumina, magnesia	1,466
Sulphide of iron	2,670
Carbon	1,800
Sand	2,000
Water	36,700
Combined water and loss	2,418

2478. Oxidized Soda, Alkali, or Vat Waste.
John Hutchinson & Co.

In Mond's process a current of air at the ordinary temperature is forced through the waste as it lies in the vats, directly the last soda liquors are drained away. The waste becomes hot, oxydizing, and forming polysulphides of calcium, hyposulphite and hydrosulphate of calcium. The waste is then lixiviated, and the liquid removed, the residue being again treated as above several times.

2479. Sulphur Liquor, the soluble portion of **Oxidized Alkali,** or **Tank Waste.** *John Hutchinson & Co.*

The oxydized waste, lixiviated in the vats with warm water, gives a yellow solution containing polysulphides of calcium, hyposulphite of calcium, and hydrosulphate of calcium.

Liquor generally contains equal to 5·0 of sulphur, distributed as follows:—

2·0 hyposulphite of calcium.
2·0 polysulphide do.
1·0 hydrosulphate do.

2480. Precipitated Sulphur, formed when sulphur liquor and muriatic acid are mixed. *John Hutchinson & Co.*

Sulphur liquor is mixed with common hydrochloric acid from the condensers, the mixed liquors being heated to 140° Fahr. and well stirred.

The muriatic acid forming chloride of calcium in the liquor, sulphur is deposited as a yellow flocculent precipitate.

In a good sample of liquor all the sulphide of hydrogen disengaged by decomposition of the sulphides reacts on the sulphurous acid liberated at the same time from the hyposulphite, sulphur and water being the products.

2481. Lump Sulphur, prepared by melting the moist sulphur of a previous stage of the process in a strong cast-iron vessel. *John Hutchinson & Co.*

After washing out the chloride of calcium from the moist sulphur, the drained product is put into a strong cast-iron cylinder, the filling-in aperture screwed down, and steam of a pressure of 35 lbs. admitted through a coil of cast-iron pipe. The sulphur rapidly melts, and at the expiration of a certain time, found out by experience, the whole charge is forced by the pressure of the steam through the discharge pipe into tight wooden wagons, and when cool broken up for sale.

2482. Roll Sulphur. The roll brimstone of commerce, used in medicine. *John Hutchinson & Co.*

Melted sulphur run into round wooden moulds and allowed to cool.

2483. Bicarbonate of Soda (lump), prepared by exposing crystals of carbonate of soda to a current of carbonic acid gas till saturated, and drying the product. *John Hutchinson & Co.*

Soda crystals, or carbonate of soda, made by dissolving the soda-ash of Leblanc's process in hot water, and, after settling, allowing to cool and crystallize, are put into an air-tight iron chamber, and carbonic acid gas (prepared by decomposing limestone with waste muriatic acid from the condensers) turned in by a pipe on the roof of the chamber. After some hours the crystals are changed into bicarbonate of soda, part of the water of crystallization escaping during the process.

The moist bicarbonate is dried in kilns heated not over 100° Fahrenheit.

2484. Bicarbonate of Soda. Carbonate of soda of the shops, used in medicine and for making effervescing drinks. *John Hutchinson & Co.*

The dry lump bicarbonate ground in a mill and dressed to separate coarse particles, as in grinding and preparing flour from wheat.

2462. Deacon's Apparatus for exposing porous materials and currents of gases to mutual action. Sectional working model, illustrating the application of one form of the apparatus to Deacon's process for producing chlorine. *Henry Deacon.*

In this example, the layer or "wall" is vertical and circular, and forms a section of a cylinder. The frames resemble those of venetian blinds, with the laths inclined at an angle of 45°, and so far apart, that an imaginary line joining the upper edge of each lath and the lower edge of the one above it is more horizontal than the natural angle of repose of the porous material itself, which is thus retained and supported by each lath in succession. A "wall" of this kind on being raised in height adds to the pressure on the bottom layers only so long as the height is less than that of a cone whose base is the width of the "wall," and whose sides are at the same angle as the natural angle of repose of the material. This increase of pressure diminishes in inverse proportion to the height, and ceases when the height of the imaginary cone is reached, all the weight of additional height above that point being borne by the retaining frames. In the model, the "wall" and framework are in a cast-iron vessel, which is heated in a brick furnace. The porous material is distributed to, and gathered from, the wall, by covering and inverted cones from, and to, central pipes. The gaseous current passes from the outside of, and through, the "walls" to the space they and the covering cone enclose, and is withdrawn from this space, or the direction of the current is reversed at pleasure.

2699. Native Peroxide of Manganese (Spanish), containing 80 per cent. of peroxide. *N. Mathieson & Co.*

2700. Hydrochloric Acid, obtained by absorbing the gaseous acid in water. *N. Mathieson & Co.*

2701. Chloride of Manganese from native "manganese" stills *after* neutralization with carbonate of lime.
N. Mathieson & Co.

2702. Limestone Dust. Crushed carbonate of lime.
N. Mathieson & Co.

2703. Manganese Mud, as precipitated *before* blowing with air. *N. Mathieson & Co.*

2704. Manganese Mud, *after* oxidation by blowing.
N. Mathieson & Co.

2705. Burnt Lime, from Buxton, Derbyshire. This lime is unslaked. *N. Mathieson & Co.*

2706. Hydrate of Lime, sifted and ready for the bleaching powder chambers. *N. Mathieson & Co.*

2707. Bleaching Powder, containing 38 per cent. of chlorine.
N. Mathieson & Co.

2724. No. 1. **Cupreous Iron Pyrites,** employed in the manufacture of sulphuric acid. *Widnes Metal Company.*

Water	·70
Sulphur	49·00
Arsenic	·47
Iron	43·55
Copper	3·20
Zinc	·35
Lead	·93
Lime	·10
Siliceous residue	·63
Oxygen, and traces of various metals	1·07
	100·00

2725. No. 2. **Burnt Ore,** or cinder remaining after the almost complete elimination of the sulphur from the pyrites as sulphurous anhydride. *Widnes Metal Company.*

Water	3·85	
Sulphur	3·76	
Arsenic	·25	
Iron	58·25	—83 per cent. Fe_2O_3.
Copper	4·14	
Zinc	·37	
Cobalt	traces	
Silver	traces	
Lead	1·14	
Lime	·25	
Oxygen and loss	26·93	
Insoluble residue	1·06	
	100·00	

2726. No. 3. **Mixture** of **Burnt Ore** and **Salt** (the latter being about 12 per cent. of the whole), ground and passed through sieve of about 16 holes per square inch.

Widnes Metal Company.

This mixture is furnaced during a period of 5¾ hours, at the expiration of which time the copper has usually been almost entirely converted into a soluble chloride of that metal.

2727. No. 4. **Mixture** of **Salt** and **Burnt Ore** after calcination during 5¾ hours. *Widnes Metal Company.*

2728. No. 5. **Purple Ore,** or residue left from No. 4 after the extraction of the copper by lixiviation with hot water and dilute hydrochloric acid. *Widnes Metal Company.*

This residue is chiefly employed for the "fettling" of puddling furnaces.

Ferric oxide	96·20 = iron 67·35 per cent.
Lead	·86
Copper	·18
Cobalt	trace
Alumina	·45
Lime	·46
Soda	·10
Phosphoric anhydride	none
Arsenic	trace
Sulphuric anhydride	·49
Sulphur	·16
Chlorine	·03
Silica	1·22
	100·15

2729. No. 6. **Purple Ore** compressed into blocks for use in the blast furnaces (the brick exhibited was made by Messrs. N. Mathieson & Co., of Widnes). *Widnes Metal Company.*

2730. No. 7. **Solution of Copper** as drawn from the lixiviators, containing, in addition to copper, &c., from three to four grains of silver per gallon, with traces of gold.

A quantity of iodide of potassium (or zinc) sufficient to precipitate the silver present is added to this solution, and the precipitate formed is allowed to subside, the supernatant liquor being passed into vessels in which the copper is precipitated by means of metallic iron.

Widnes Metal Company.

ANALYSIS of COPPER SOLUTION of Sp. Gr. 1·24.

	Contents per gallon. Grains.
Sodium sulphate	10,092
Sodium chloride	4,474
Chlorine (combined with metals)	4,630
Copper	3,700
Zinc	480
Lead	40
Iron	32
Lime	52
Silver	3·06

Arsenic, antimony, bismuth, &c. not estimated.

2731. No. 8. **Precipitate** caused by addition of a soluble iodide to solution of copper, &c. (Claudet's process), consisting of iodide of silver mixed with various salts of lead, chiefly sulphate.
Widnes Metal Company.

2732. No. 8A. **Silver Precipitate,** obtained by the reduction of the iodide by means of metallic zinc.
Widnes Metal Company.

Silver	5·95
Gold	·06
Lead	62·28
Copper	·60
Zinc oxide	15·46
Ferric „	1·50
Lime	1·10
Sulphuric anhydride	7·68
Insoluble residue	1·75
Oxygen and loss	3·62
	100·00

2733. No. 8B. **Iodide of Zinc,** obtained by reduction of iodide of silver by metallic zinc, and used for the treatment of a further quantity of argentiferous copper solution.
Widnes Metal Company.

2734. No. 9. **Copper Precipitate** thrown down by the immersion of thin scrap iron in the cupreous solutions.
Widnes Metal Company.

(Contains on an average 75 to 80 per cent. of metallic copper.)

2735. No. 10. **Spent Liquor,** or liquid remaining after complete precipitation of copper from solution. This liquor is run to waste. *Widnes Metal Company.*

2459. Spence's Process for the Manufacture of Alum. Specimens to illustrate the process, consisting of :—

(1.) Shale of the coal measures before calcination (source of alumina).
(1*a*.) Shale after calcination.
(2.) Pyrites or bi-sulphide of iron (source of sulphur for the manufacture of sulphuric acid).
(2*a*.) Nitrate of soda, for oxidising the sulphurous acid produced from the pyrites into sulphuric acid.
(2*b*.) Sulphuric acid, specific gravity 1·6, as used in the manufacture of alum.
(3.) Gas liquor (source of ammonia).
(3*a*.) Sulphate of ammonia.
(4.) Sulphate of alumina.
(5.) First crystals of ammonia alum (a double salt or compound of sulphate of ammonia and sulphate of alumina).
(6.) Ammonia alum. Second and final crystallisation.

Peter Spence.

2473. Specimens of Alum Crystals.

3 Crystals of potash-alum.
3 ,, ,, ,,
10 ,, ,, ,,
4 Crystals of chrome-alum.
2 ,, ,, ,, covered with potash-alum.
1 Crystal of potash-alum of 5 kilo.
1 ,, ,, ,, 3½ kilo.

H. B. J. van Rijn, Venlo, Netherlands.

2679. Chlorate of Potash. Muriate of potash containing about 90 per cent. chloride of potassium, and some impurities consisting of chloride of sodium, sulphates of potash, soda, lime, and magnesia.

James Muspratt & Sons.

2680. Chlorate of Potash. Milk of lime of about 1·08 specific gravity, made by well stirring up about 18 ctr. slacked lime in about 6,800 litres water in a cast-iron vessel. The sample contains a small quantity of chlorate and of chloride of calcium from the previous solution made in the same vessel.

James Muspratt & Sons.

2681. Chlorate of Potash. Solution of chlorate of lime of about 1·15 specific gravity, containing at the same time chloride of calcium in the molecular proportion of about 1·5. Obtained by saturating milk of lime with chlorine gas. Towards the end of the process the temperature rises, when permanganate of lime is formed owing to the small quantity of manganese contained in the lime, by which the liquor obtains its pink colour. One litre contains from 45–48 grammes of chlorate of lime.

James Muspratt & Sons.

2682. Chlorate of Potash. Finished ground chlorate of potash, containing about 0·022 per cent. chloride of calcium, and about 0·125 per cent. moisture. *James Muspratt & Sons.*

2683. Chlorate of Potash. First crystals of chlorate of potash, containing about 85 per cent. chlorate of potash, and 3–4 per cent. chloride of calcium. *James Muspratt & Sons.*

2686. Chlorate of Potash. First mother liquor of chlorate of potash, of about 1·3 specific gravity. The solution of chlorate of lime is boiled down with a sufficient quantity of muriate of potash, and allowed to cool and crystallize for 8–10 days.

James Muspratt & Sons.

2684. Chlorate of Potash. Finished crystals of chlorate of potash, containing about 0·0502 per cent. chloride of calcium.

James Muspratt & Sons.

2685. Chlorate of Potash. Last mother liquor of chlorate of potash, of 1·35–1·40 specific gravity. The first mother liquor is boiled down still further, and allowed to cool and crystallize again for 8–10 days. It contains 30–40 grammes chlorate of potash, about 520 grammes chloride of calcium, and 3–5 chloride of potassium in the litre. *James Muspratt & Sons.*

2687. Caustic Soda Ash, containing about 12 per cent. caustic soda, 76–80 per cent. carbonate of soda, total strength about 54–56 per cent. Na^2O. Black ash is lixiviated in iron tanks, the liquor thus obtained is boiled down in open wrought-iron pans, and, as the crystals fall, they are fished out and calcined in an open furnace. *James Muspratt & Sons.*

2688. Nitre Cake, obtained in the manufacture of sulphuric acid by decomposing nitrate of soda with sulphuric acid. It is composed of sulphate of soda, together with small quantities of sulphate of iron, lime, and magnesia, of chloride of sodium, nitrate of soda, undecomposed nitrate of soda, and free sulphuric acid.

James Muspratt & Sons.

2718. No. 1. **Alkaline Silicate of Soda** (glass), suitable for soap making. *William Gossage & Sons, Lancashire.*

Composition :—

100 parts, Na_2O.
180 „ SiO_2.

2719. No. 2. **Silicate** of **Soda** (glass), suitable for calico printing. *William Gossage & Sons.*

Composition :—

100 parts, Na_2O.
310 „ SiO_2.

2720. No. 3. **Silicate** of **Potash** (glass). *William Gossage & Sons.*

Composition :—

100 parts, K_2O.
310 „ SiO_2.

2721. No. 4. **Solution** of **Alkaline Silicate** of **Soda,** made from No. 1. 1,500 specific gravity. *William Gossage & Sons.*

2722. No. 5. **Solution** of **Silicate** of **Soda,** 1,375 specific gravity. Made from No. 2. *William Gossage & Sons.*

2723. No. 6. **Solution** of **Silicate** of **Potash,** 1,350 specific gravity. Made from No. 3. *William Gossage & Sons.*

2738f. Examples of Technological Diagrams.

Diagram 6. Retort for the manufacture of coal gas.
„ 7. „ „ „
„ 28. Extraction of zinc (Silesian furnace).
„ 31. Lime-kiln (continuous process).
„ 32. Lead smelting (German cupellation hearth).
„ 36. Lead smelting blast furnace.
„ 37. Extraction of salt by evaporation of brine.
„ 38. „ „ Graduation house.
„ 50. Manufacture of steel by cementation.

The Council of the Yorkshire College of Science, Leeds; Prof. Thorpe.

2460. Oxalic Acid. Two specimens. One crystallised from a solution containing sulphuric acid, the other from an aqueous solution. *Roberts, Dale, & Co.*

This product is made by the action of caustic potash, or a mixture of caustic potash and caustic soda on woody fibre (sawdust). The result of this action is oxalate of potash. The oxalic acid is isolated by precipitation as oxalate of lime, and the subsequent decomposition of this latter product by sulphuric acid. Specimen No. 2 is crystallised from water. A comparison will show the marked difference in crystalline form due to the presence of sulphuric acid.

2461. Binoxalate of Potash. *Roberts, Dale, & Co.*

2463. Carbolic Acid, chemically pure, free from taste and smell of tar, and fusing at 108° Fahrenheit. Specially prepared for internal medicinal use. *F. C. Calvert & Co.*

2464. Carbolic Acid, crystallised, fusing at 95° Fahrenheit. Specially prepared for external medical application.
F. C. Calvert & Co.

2465. Cressylic Acid, used for disinfecting purposes.
F. C. Calvert & Co.

2466. Sulpho-Carbolates. A series of pharmaceutical products, comprising sulpho-carbolates of potash, soda, ammonia, lime, iron, copper, and zinc. *F. C. Calvert & Co.*

2467. Carbolic Acid Preparations, comprising carbolic acid soap, carbolic acid disinfecting powder, and carbolised tow.
F. C. Calvert & Co.

2468. Picric Acid Crystals and paste, Aurine (rosolic acid). Used in the arts. *F. C. Calvert & Co.*

2475. Chemicals for use in various Manufactures.

- Liquid archill, made from Orchella weed, for dyers and printers.
- Sulphate of alumina, for sugar refiners, paper makers, and dyers.
- Aluminous cake, for paper makers.
- Cudbear, made from Orchella weed, for dyers.
- Bichromate of potash, with samples of chrome ore, limestone, and sulphate of potash, from which it is made.

W. J. Norris and Brother.

2476. Aniline and other Chemical Products used for Dyeing. *Brooke, Simpson, and Spiller.*

		Commercial Name.
Rosaniline base	$C_{20}H_{19}N_3, H_2O$	——
Rosaniline hydrochlorate	$C_{20}H_{19}N_3HCl$	Roseine crystals.
Crysaniline	$C_{20}H_{17}N_3$	Phosphine.
Methyl-rosaniline acetate	$\left\{\begin{matrix}C_{20}H_{18}\\ CH_3\end{matrix}\;N_3\right\}C_2H_3O_2$	Hofmann violet.
Tri-methyl rosaniline acetate	$\left\{\begin{matrix}C_{20}H_{16}\\ CH_3\\ CH_3\\ CH_3\end{matrix}\;N_3\right\}C_2H_3O_2$	Eclipse violet.
Dimethyl-phenyl-rosaniline acetate	$\left\{\begin{matrix}C_{20}H_{16}\\ C_6H_5\\ CH_3\\ CH_3\end{matrix}\;N_3\right\}C_2H_3O_2$	Spiller purple.
Phenyl-rosaniline hydrochlorate	$\left\{\begin{matrix}C_{20}H_{18}\\ C_6H_5\end{matrix}\;N_3\right\}HCl$	Imperial violet.
Tri-phenyl-rosaniline hydrochlorate	$\left\{\begin{matrix}C_{20}H_{16}\\ C_6H_5\\ C_6H_5\\ C_6H_5\end{matrix}\;N_3\right\}HCl$	Pure opal blue.

		Commercial Name.
Sodium tri-phenyl-rosaniline sulphonate - - - -	$\left\{\begin{matrix}C_{20}H_{16}\\C_6H_5\\C_6H_5\\C_6H_5\end{matrix}\; N_3\right\}NaSO_3$	Fast blue, 6B.
Tri-phenyl-rosaniline sulphonic acid - - - - -	$\left\{\begin{matrix}C_{20}H_{16}\\C_6H_5\\C_6H_5\\C_6H_5\end{matrix}\; N_3\right\}HSO_3$	—
Sodium phenyl-rosaniline sulphonate - - - -	$\left\{\begin{matrix}C_{20}H_{18}\\C_6H_5\end{matrix}\; N_3\right\}NaSO_3$	Alkali violet.
Di-phenyl-rosaniline acetate -	$\left\{\begin{matrix}C_{20}H_{17}\\C_6H_5\\C_6H_5\end{matrix}\; N_3\right\}C_2H_3O_2$	Atlas blue.
Calcium tri-phenyl-rosaniline disulphonate - - - -	$\left\{\begin{matrix}C_{20}H_{16}\\C_6H_5\\C_6H_5\\C_6H_5\end{matrix}\; N_3\right\}Ca(SO_3)_2$	Soluble blue.
Methyl-rosaniline hydrochlorate (fused) - - - -	$\left\{\begin{matrix}C_{20}H_{18}\\CH_3\end{matrix}\; N_3\right\}HCl$	Hofmann violet cake R.
Di-methyl-rosaniline hydrochlorate (fused) - - -	$\left\{\begin{matrix}C_{20}H_{17}\\CH_3\\CH_3\end{matrix}\; N_3\right\}HCl$	Hofmann violet cakeBB.
Rosaniline hydrochlorate (fused) -	$C_{20}H_{19}N_3HCl$	Roseine cake.
Tri-methyl-rosaniline methyl iodide - - - - -	$\left\{\begin{matrix}C_{20}H_{16}\\CH_3\\CH_3\\CH_3\end{matrix}\; N_3\right\}(CH_3I)^3$	Iodine green crystals.
Anthracene - - - -	$C_{14}H_{10}$	Anthracene.
Alizarin - - - -	$C_{14}H_8O_4$	Alizarin (blue shade).
Anthrapurpurin - - -	$C_{14}H_8O_5$	Alizarin (red shade).

2476a. Chrysoidine, a new basic orange dye for silk, wool, cotton, leather, &c. Manufactured by the exhibitors.

Williams, Thomas, and Dower.

Chrysoidine is, according to quality, the sulphate or hydrochlorate of a new bi-acid base, belonging to the benzene series. It is a valuable orange-yellow, and owing to the readiness with which it crystallizes, can be obtained in a state of perfect purity. Except phosphine, it is the only basic yellow dye known, and as it is the result of a direct process (not a secondary product) it can be obtained at a much lower price than phosphine, which it equals, and in some of its applications surpasses in strength and beauty of shade. It dyes in neutral or slightly basic baths, and has a great affinity for silk, wool, and even for unmordanted cotton. Mordanted cotton is dyed a yellow or orange shade according to the mordant employed. It combines readily with magenta and other red colours, giving rise to very clear and beautiful scarlets. The chrysoidine was discovered quite recently in our laboratory by Dr. Otto N. Witt.

2450a. Models of **Stoneware Distilling Apparatus** as used by **Manufacturing Chemists,** and others, and comprising still, still head, false arm, dip arm, condensing worm, three receivers with connecting pipes and taps, mixing pan, and stone jar. Made of improved vitrified stoneware, and warranted to resist the action of the strongest acids. *James Stiff & Sons.*

2450b. Model of Hofmann's Patent Kiln.

Hermann Wedekind.

2450c. Drawing of Bull's Patent Kiln.

Hermann Wedekind.

2566a. Drawing of Price's Patent Retort Furnace.

W. Price.

DESCRIPTION OF DRAWING.

Fig. 1.—Longitudinal section through centre of furnace.

Fig. 2.—Plan through the "retort," "combustion," and "heating" chambers.

Fig. 3.—Cross section through combustion chamber.

Fig. 4.—Elevation, part in section, of the retort chamber.

Fig. 5.—Sectional plan through retort chamber at E E.

Fig. 1.—A is a combustion chamber filled with grate bars in the ordinary way. B, a heating chamber, separated from A by the usual bridge. C, is the neck descending into an underground flue D, leading into an upcast or retort chamber, as it has been designated, E. In the centre of the chamber (E) is a firebrick circular pillar F, with spaces around marked in Fig. 5, E E E E, and on which is placed a cast-iron cylindrical air-vessel G, which is protected by fire-brick.

On this air vessel (G) is built a retort H, partly of fire-brick, partly of cast iron. The top of the cast-iron part of the retort is fitted with a hopper, I, in the throat of which is a damper, J, worked by a rocking shaft and lever, K, from the ground.

The lower portion of the retort made of fire-brick has two necks, L L, the one leading to the combustion chamber for the passage of fuel, the other to the outside of the furnace for the insertion of stoking tools, to force the fuel forward into the combustion chamber. The entrance of the outer neck is closed by an air-tight door M. The upcast or retort chamber (E) extends to near the top of the retort, where it is closed by brickwork, but is opened at the side by the flue N, leading to the stack O.

Near the bottom of the chamber E, and in a line with the centre of the circular air vessel G, are pipes P P, inserted in the walls of the chamber (E), passing all round the chamber as shown in Fig. 5. In front of the inner side of the circuit of pipes, and opening into the chamber E, are a number of port-holes Q Q Q (see Fig. 5), leading to the space around the pipes (P P), which space affords scope for expansion and a free circulation of heat. These pipes (P P) are connected with the blast as shown at E, Fig. 4, and pass into the central chamber G, as shown at F, Fig. 5, the outlet, R, from the air vessel leads into the ash-pit S.

The practice in working is to light a fire on the grate-bars, and generate heat in the usual manner, until the furnace is well heated. The retort is then filled with fuel, and the firing commences from the retort, and by the time the fuel at the top descends to the bottom of the retort, it is well heated, and a continuous supply of heated fuel is then kept up. All raw fuel is from this time supplied to the hopper (I) only, and let into the "retort" by the damper without the access of air.

The gases so generated in the combustion chamber (A) pass over the bridge into heating chamber (B), down the neck (C), into the underground flue (D), into the upcast or "retort" chamber (E), filling the spaces around, and giving up their heat to the circular air chamber (G), the retort (H), and the air pipes (P P), and their residue passing off by way of the flue (N) into the stack (O), the heat so stored being carried back into the furnace by the heated fuel. Combustion is supported by air under pressure from a fan. The air entering in as shown at (E), Fig. 4, traverses the entire circuit of pipes, passing into the central air-vessel (G), out through the outlet (R), into the ash-pit (S), and so up through the grate-bars.

2664. Description and drawing of an **Apparatus** for the **Determination** of **Sulphur** (see the accompanying treatise: "Aphorismen über Steinkohlen von Dr. E. Muck.")
Berggewerkschaftskasse, Bochum, Rhenish Prussia.

2665. Reich's Apparatus for **estimating Sulphuric Acid.** *Royal Mining Academy, Freiberg, Saxony.*

2661. Collapsing Aspirator, of vulcanised rubber, for rapid gas analysis. Arranged to measure the gas to be examined and to contain the absorbent. On agitation, the gas and absorbent are brought into contact. Used by H.M. Inspectors of Alkali Works. *Alfred E. Fletcher.*

2566. Winkler's Apparatus for gas analysis.
Franz Hugershoff, Leipzig.

One is intended for relatively small quantities of gases, carbonic acid, &c. Its advantage consists in the considerably narrowed part of the measuring tube above the lower three-way stop-cock, whereby finer divisions are rendered possible.

The other is constructed with a second three-way stop-cock, in the upper part of the measuring tube, which allows for the easy connexion with any other apparatus.

2666. Winkler's Apparatus for technico-chemical **Gas Analysis.** *Royal Mining Academy, Freiberg, Saxony.*

2736. Max Liebig's Apparatus for determining, for technical purposes, the quantity of oxygen and carbonic acid contained in various gaseous mixtures.
Rhenania Alkali Works, Stolberg, near Aix-la-Chapelle.

A description of this apparatus will be found in Ding. Polyt. Journ., Jan. 1873, of which copies may be had.

2597. Dittrich's Apparatus for the **Volumetric Determination** of **Gases,** accompanied by a printed description, together with a drawing and 5 tables. *J. H. Büchler, Breslau.*

This apparatus may be used for scientific as well as technical determinations of the carbonic acid contained in chalk, bone charcoal, &c., and is extensively used in the sugar refineries of Germany and Russia.

2520. Fixed appliance for the analysis of gases with three reagents. *M. Orsat, Paris.*

2521. Fixed appliance for the analysis of gases with two reagents. *M. Orsat, Paris.*

2522. Portable Appliance for the analysis of gases, giving the quantity of gases, giving the quantity of the hydrogen and its carburets. *M. Orsat, Paris.*

2454. Apparatus for Gas Analysis. By M. Orsat, of Paris. *Robert Galloway.*

The apparatus is so constructed as to be readily available for the use of ordinarily intelligent workmen, and to furnish not only ready but comparatively trustworthy indications.

2740a. Rudorff's Apparatus for determining the carbonic acid in illuminating gas.

W. J. Rohrbeck and F. Luhme and Co., Berlin, Dr. Herm. Rohrbeck.

This apparatus consists of a three-necked Woulff's jar, of about 1,000 cc. capacity.

Into one of the necks is ground a tube (*a*), reaching nearly to the bottom, which can be closed by a stop-cock, whilst the second neck is closed by a glass-cock burette, divided into cc., and the third by a manometer. In the lower part a cock is fixed, perforated in such a manner that the interior of the bottle can be brought into connexion either with the open air by closing the manometer, or with the manometer alone.

The apparatus, the volume capacity of which has been previously ascertained by weighing with distilled water, is thereupon filled with the gas to be examined in such a manner as to allow the gas to flow in through the pipe reaching nearly to the bottom of the jar, by means of a tube, whilst at the same time the air in the apparatus escapes through the cock attached to the manometer. When it is supposed that the jar has been completely filled with the gas, first the outside air is shut off by means of the manometer cock by which the same is brought into connexion with the interior of the jar, and next the gas supply pipe. The difference of pressure occurring at the moment the connexion is being shut off, which can be observed on the manometer, must be equalised by carefully opening the manometer cock, whereupon the gas can be tested as to the per-centage of carbonic acid contained in it.

It is advisable, in order to remove the disturbing influence of the changes in the temperature, to surround the glass jar with water of the same temperature as that of the room. After a lapse of three or four minutes at the utmost, the interior of the jar with the surrounding water will have assumed the same temperature, as can be easily ascertained by thermometers attached within and without.

The principle of determining the carbonic acid is, that the carbonic acid is allowed to be absorbed by potash-lye, and then replaced by an equal volume of potash-lye.

By opening the glass-cock of the burette, some drops of potash-lye are put into the jar. At the first moment the pressure will be increased, which, however, is soon lessened by the absorption of the carbonic acid. Thereupon potash-lye is dropped in in the same quantity as the absorption of the carbonic acid is consumed, so that the position of the indigo solution in the manometer remains the same.

Where the absorption of the carbonic acid is completed, it will be necessary to wait for a few minutes, and in case there is still a difference of pressure, to drop in so much of potash-lye that the manometer show again exactly its first position.

The volume of carbonic acid having been replaced by potash-lye, this volume can be read on the burette.

As the capacity of the jar is known,—at Rudorff's experiments with this apparatus it contained 8·80 cc.,—there will be necessary of potash-lye :—

at 1 per cent. volume of carbonic acid	8·80 cc.
at 2 „ „ „ „	2·88 =
at 3 „ „ „ „	3·88 cc.

In order to form a judgment on the exactness of this method, Rudorff filled the jar with hydrogen and carbonic acid of known strength, and thus he obtained :—

	Found.	Calculated.
1 per cent. Co_2	8·7 cc.	8·8
2 „ „	17·8	17·6
3 „ „	26·8	26·4
4 „ „	35·1	35·2

Some consecutive experiments made with illuminating gas, resulted in consumption of potash-lye :—

12·0 cc. = 1·36 per cent.
12·1 cc. = 1·37 „ „
11·8 cc. = 1·34 „ „

The apparatus, of course, is only intended for ascertaining small quantities of carbonic acid, such as is the case with illuminating gas. The other component parts of gas are of no perceptible influence on this method.

The analyses mentioned prove this sufficiently in order to secure for a method a certain adoption in practice, which recommends itself just as well by its trustworthy results, as by easy and speedy execution.

2456f. Tube with **Beads** to collect the **Ammonia** in **Coal Gas** as used at the testing stations. *E. Cetti & Co.*

2737. Demby's Amylometer (potato-tester) accompanied by a description and case. *J. H. Büchler, Breslau.*

This instrument is quite new (1875). It is remarkable for its simplicity and accuracy, as well as for the rapidity with which the starchy matter in potatoes can be estimated. Rain water may be employed.

2738. Stammer's Testing Apparatus applicable to all the processes met with in distilleries, accompanied by a descriptive treatise. *J. H. Büchler, Breslau.*

This apparatus is quite new. It comprises absolutely true standard hydrometers for the determination of specific gravities, and replaces (for the most part) the purely empirical methods of testing which have hitherto been in use, by rational chemical methods.

2667. Soleil-Scheibler improved **Polarising Apparatus** (or optical saccharoetmer) for determining sugars.
Dr. C. Scheibler, Berlin.

All the instruments exhibited by Dr. C. Scheibler are for the use of chemical laboratories in beet-root sugar refineries. They are described in the "Journal "of the Society for the Advancement of the Beet-root Sugar Industry of the "German Empire," edited by the exhibitor, and are used in the chemical laboratory of the society of which Dr. C. Scheibler is the director.

The Soleil-Scheibler Polariscope, serves for the determination of the optical rotary power of sugar solutions, besides ascertaining quantitatively the amount of the sugar contained therein. The improvements made by the exhibitor in this instrument (and described in the Zeitschrift for 1870, p. 609) are as follows:—

(1.) In the place of the two quartz-wedges sliding against one another in the earlier instruments, and which carry the scale and vernier, these instruments have the wedges so arranged that only one of them carrying the scale is movable, the other bearing the vernier is fixed. By this means a much firmer motion of the first wedge is secured, and the so-called dead-motion of the setting-screw does not easily occur. In consequence of this the zero point of both wedges remains unaltered, which is a matter of considerable importance.

(2.) The above-mentioned vernier resting on a firmly fixed quartz-wedge is movable within definite dimensions, by means of a key, without the position of the wedge itself being changed. In this way an accurate adjustment to the zero point is easily accomplished.

(3.) For the more convenient reading off of the experimental numbers obtained, a small round magnifying mirror is fixed above the scale.

(4.) To prevent any side rays interfering with the readings, all light is kept out by a completely light-tight sliding casing fitted over the observation tubes.

2668. Mitscherlich's simple Polarising Apparatus for use in sugar refineries. *Dr. C. Scheibler, Berlin.*

2669. Scheibler's Apparatus for the **estimation** of **Carbonate** of **Lime** in bone charcoal, as well as for the quantitative volumetric analysis of carbonates generally.
Dr. C. Scheibler, Berlin.

This apparatus was described by Scheibler in the above-mentioned Zeitschrift for 1859, p. 285, and for 1861, p. 525.

2670. Scheibler's Apparatus for the **volumetric estimation** of **Carbonic Acid** contained in the gases of saturated solutions. *Dr. C. Scheibler, Berlin.*

Described in Zeitschrift for 1866, p. 644.

2671. Scheibler's Apparatus for estimating the **Refinery Value of raw Sugar.** *Dr. C. Scheibler, Berlin.*

Described in Zeitschrift for 1872, p. 297, and 1873, p. 304.

2672. Stammer's Colorimeter for estimating the **Colour of Liquids.** *Dr. C. Scheibler, Berlin.*

2673. Hydrostatic Balance for estimating the **Density of Sugar** solutions and other liquids. *Dr. C. Scheibler, Berlin.*

Described in Zeitschrift for 1870, p. 264.

2674. Brix's Standard Saccharometer, consisting of three hydrometer tubes and a thermometer packed in a case.
Dr. C. Scheibler, Berlin.

2675. Gerlach's Standard Saccharometer.
Dr. C. Scheibler, Berlin.

2676. Scheibler's Muffle of platinum, together with platinum Scales and Stand used for the estimation of the ash in raw sugars.
Dr. C. Scheibler, Berlin.

Described in Zeitschrift for 1867, p. 338.

2476b. Card with three patterns of dyed cloth.
Messrs. J. Marshall, Son, & Co.

Orchella weed.
Moss Teneriffe.
Orchella weed, Ceylon.
  Do. do. Zanzibar.
  Do. do. Cape de Verde.

Bottle of Cudbear, red shade.
  Do. Orchill liquor.
  Do. do. paste.
  Do. Cudbear, violet shade.

2450c. Two Bink's Alkalimeters with registered enamel back. *E. Cetti & Co.*

2450d. Nitric Acid Tube with graduated enamel back.
E. Cetti & Co.

2738e. Artificial Fruit Essences, being solutions of various organic ethers in rect. spirit of wine. *Hirst, Brooke, and Hirst.*

They are nearly identical in flavour and chemical composition with the flavouring principles of the fruits they are intended to imitate:—

Jargonelle pear.
Pine apple.
Apple.
Strawberry.

Raspberry.
Greengage.
Peach.
Cherry.

2665a. Collection of Chemical Substances.
Messrs. Bouck & Co.

Sulphate of copper; copper precipitate; copper oxide; agricultural sulphate of copper; nitrate of lead; sulphate of ammonia; sulphate of zinc; red prussiate of potash; yellow prussiate of potash; crude sulphur; roll sulphur; flour sulphur; crude carbolic acid; coal tar solvent naphtha; coal tar creosote; benzole 90°/$_0$; benzole 50°/$_0$; anthracene; anthracene oil; naphthaline; pitch.

VI. MODELS, DIAGRAMS, AND APPARATUS ILLUSTRATING PROCESSES AND RESEARCHES IN AGRICULTURAL CHEMISTRY; APPARATUS, DIAGRAMS, &c., ILLUSTRATING THE CHEMISTRY OF THE GRAPE VINE.

2741. Specially made Balance, and other appliances, used in an investigation by Messrs. Lawes and Gilbert, to determine the amount of water given off by plants during their growth. See Journal of the Horticultural Society of London, vol. v., p. 38, 1850, and vol. vi., p. 227, 1851. The experiments were, however, continued to 1858, inclusive. *John Bennet Lawes.*

The balance, which was made by Mr. Oertling, of London, was constructed to turn with less than one grain, when loaded with 50 lbs., or even more, on each side. This it accomplished, but it was found that the quantity of water given off by the plants during their growth was so great that such accurate weighing was not necessary. In fact, during the whole period of growth, as much as from 15 to 20 lbs. of water was in some cases given off from a single jar of plants, and during the most active periods of growth as much as from 1,500 to 2,000 grains per day. In the earlier experiments the vessels in which the plants were grown were made of glass, but afterwards of zinc. There was no opening at the bottom for drainage. The top was closed by a glass plate, firmly cemented to the rim, but having a hole in the centre for the plants to grow through, and another, smaller one, nearer the side by which to supply weighed quantities of water as needed, but which was, at other times, closed by a cork. To prevent, as far as possible, evaporation from the soil other than through the plant itself, small pieces of glass were laid over the centre hole, close up to the stems of the plants as they grew. Each jar held about 42 lbs. of soil. A standard leaden counterpoise was kept in the weight pan, and only the deviations above or below its weight were determined; a set of weights, from 10,000 grains down to one-tenth of a grain, being provided for the purpose. The weighings were generally taken at intervals of 10 days, but sometimes at shorter periods.

The list of plants experimented upon included wheat, barley, beans, peas, clover, mangold wurzel, turnips, and various evergreen and deciduous trees.

2742. Case of Casts of White Silesian Sugar-beet, illustrating the influence of different manures on the amount of produce, and on the per-centages of dry matter and of sugar in the roots. First season of the experiments, 1871. *John Bennet Lawes.*

2743. Table of **Average Results** obtained on growing the crop (sugar-beet) five years in succession on the same land. *John Bennet Lawes.*

The experiments were conducted on the farm of John Bennet Lawes, Esq., Rothamsted, near St. Albans.

2744. Apparatus used in an investigation by Messrs. Lawes, Gilbert, and Pugh, to determine whether plants assimilate free or uncombined nitrogen; with drawings of some of the plants grown. See Philosophical Transactions, Part 2, p. 493, 1859; and Journal of the Chemical Society, new series, vol. i.; Entire Series, vol. xvi., 1863. *John Bennet Lawes.*

The tap being opened, and water allowed to flow from a raised reservoir into the large stoneware Woulfe's bottle, air passes from it by the small leaden exit tube, through two glass Woulfe's bottles containing sulphuric acid, then through the long tube filled with fragments of pumice saturated with sulphuric acid, and, lastly, through a Woulfe's bottle containing a saturated solution of ignited carbonate of soda; and, after being so washed, the air enters the glass shade, from which it passes by an exit tube through an eight-bulbed apparatus containing sulphuric acid, by which communication with the unwashed external air is prevented. Entering the shade at the side opposite to this exit tube is a tube for the supply of water or solutions to the soil, but which is at other times closed. In front of the shade is a bottle connected by a tube with the bottom of the earthenware lute-vessel, for the collection of the condensed water, which is from time to time withdrawn from the bottle by suction, and returned to the soil. The shade enclosing the pot and plant stands in the groove of a specially made, hard-baked, glazed, stoneware lute-vessel, mercury being the luting material. Carbonic acid is supplied as occasion may require, by adding a measured quantity of hydrochloric acid to the bottle containing fragments of marble, the evolved gas being, as will be seen, washed through one of the bottles of sulphuric acid, through the long tube, and through the carbonate of soda solution, before entering the shade. The short leaden pipe, bent and opening downwards externally to the large stoneware bottle, passes nearly to the bottom of it inside, and is a safety tube for the overflow of the water when the vessel is full, and so to prevent it passing into the wash bottles, &c. When full, the cork near the bottom of the stoneware vessel is withdrawn, and the water flows by means of a drain back into a tank, from which it is pumped into the raised reservoir for re-use. It will be observed that, by the arrangement described, the washed air is forced, not aspirated, through the shade, and the pressure being thus the greater within the vessel, the danger of leakage of unwashed air from without inwards is lessened. In 1857 twelve sets of such apparatus were employed, in 1858 a larger number, some with larger lute-vessels and shades, in 1859 six, and in 1860 also six. The whole were arranged side by side in the open air, on stands of brickwork, as indicated.

2744a. Apparatus for Analysing Soil.
Herr Bela Gonda, Magyar, Ovar, Hungary.

2744b. Eight Bottles of Specimens illustrating constituents **of Cotton Fibre** and case containing 14 glass bottles.
Dr. Schunck, Owen's Coll., Manchester.

Film of colouring matter mounted between two pieces of glass.

Pamphlet on constituents of cotton fibre.

2534a. Azotometer arranged for the easy and exact determination of the nitrogen contained in the manures employed in agriculture. *M. Honzeau, Paris.*

2564. Knop's Improved Azotometer.
Franz Hugershoff, Leipzig.

2583. Knop's Azotometer, as modified by Dr. Wagner.
Ehrhardt and Metzger, Darmstadt.

Described in "Zeitschrift für anylitiche Chemie von Fresenius," 1874, 4 Heft; 1876, 3 Heft.

2760a. Ebullioscope, for weighing alcohol in wines, Vidal's system, improved. *M. Malligand fils, Paris.*

The improved Ebullioscope of M. Malligand fils, is an instrument for ascertaining easily and correctly, in a few moments, without distillling, and merely by ebullition, the quantity of alcohol contained in dry or sweet wines. It is now used by the Syndical Chamber of the Wine Trade of Paris, who have found the Ebullioscope to be the most practical and most correct instrument of all those used hitherto for ascertaining the alcoholic properties of wines. (Sittings of 7th July and 6th October 1874.)

Declared by the Institute of France to be the best process known hitherto for weighing alcohol in wines. (Report of the Academy of Science, vol. 80, No. 17. Sittings of 3rd May 1875.)

Set of Tephrylometers. *Dr. Herbert Major.*

APPARATUS, DIAGRAMS, &C., ILLUSTRATING THE CHEMISTRY OF THE GRAPE VINE, EXHIBITED BY PROF. DR. LEONARD ROESLER, KLOSTERNEUBURG.

2745. Model of Apparatus, designed to impregnate divers fluids, *e.g.*, must, wort, &c., with air, before fermentation.

2746. Diagram, exhibiting the results of analysis of must, grapes, and trial-manurings, 10 tables.

To render the proportions of the various substances more conspicuous, their quantities are represented by curves.

2747. Grape-growing Map of Tyrol, with results of analysis of Tyrolean wines at the station.

2748. Grape-growing Map of Portugal, with results of chemical analysis of Portuguese wines.

2749. Results of Wine Analysis, with specimens of chemicals.

2750. Wine Ashes, prepared by means of electricity, by Dr. Roesler.

2751. Apparatus for Calcination, after a design by Dr. Roesler.

2752. Apparatus for Wine Analysis, in box.

2753. Apparatus for studying the Influence of Electricity upon Wine.

2754. Cheap Electric Battery, adapted for electrolytical experiments.

2755. Pneumatic Pump, with arrangement by which the sap of plants can be extracted, devoid of air, for studying the influence of oxygen upon fermentation.

2756. Apparatus for the Filtration of Fruit-saps, without oxygen.

2757. Diagram, showing the results of water analysis, with special reference to apparatus for determining nitric acid.

2758. Diagrams (5), illustrating apparatus employed in experiments on the growth and respiration of grape vines and fruit.

2759. Two Portfolios, containing diagrams referring to wine analysis, microscopical research, the laboratory fittings for fermentation, &c., at the experimental station.

2760. Soil Thermometer of peculiar construction.

VII.—METALLURGY.

2772. Old Cupellation Furnace, supposed to have been the one used by Sir Isaac Newton, when Master of the Mint, in some experiments on the cupellation of silver. *The Master of the Mint.*

In general construction it is precisely similar to those now in use, the only difference being that, in modern forms, more perfect means are adopted for regulating the draught.

2773. Touchstone for the Assay of Gold, formerly used in the Royal Mint. *The Master of the Mint.*

The method is based on the fact that the greater the amount of gold contained in an alloy, the brighter is the gold yellow colour of a streak drawn with it on a black ground, and the less is it attacked by pure nitric acid or by a "test" acid. In ascertaining the richness of the alloy under examination its streak is compared with marks drawn with alloys whose richness is accurately known.

2770. Case showing successive processes of Gold Assaying.

1. Tray on which assays are placed when ready for the furnace.
2. Muffle containing cupels.
3. Tray for annealing the buttons after being rolled or flatted.
4. Tray of platinum cups for "parting" the assays.
5. Platinum boiler in which the assays are treated with strong nitric acid.
6. Assay balance, capable of indicating the $\frac{1}{3000}$th of a grain when loaded with 7·5 grains in each pan.
7. Mould for making cupels, each of which holds four assays.
8. Cupel tongs.
9. Assay tongs. *The Master of the Mint.*

The process of gold assaying comprises six distinct operations.

1st Process.—The portion of metal to be assayed is adjusted to an exact weight by cutting and filing (*see* specimen A. in Case). Such accurately weighed portions of alloy are wrapped, together with definite weights of pure silver (B), in capsules of lead foil (C C[1]), and placed in order on a tray, 1.

2nd Process.—The packets are transferred to porous cups or "cupels" of phosphate of lime, which are arranged in rows, corresponding to those on the tray, in a muffle or small oven, 2, which is fixed in a suitable furnace and maintained at a bright red heat. The lead oxidizes and is absorbed by the cupel, together with the copper and other oxidizable metals present, and the silver and gold remain behind in the form of a button (D), which may also contain platinum, iridium, or other metals possessing similar properties.

3rd Process.—These buttons are hammered out into discs (E), which, after being annealed, are rolled into thin strips (F), and these are again annealed and bent into loose coils or "cornets" (G). The annealing takes place in an iron tray, 3.

4th Process.—The cornets are placed in small perforated cups of platinum arranged in a perforated tray of the same metal, 4. The whole is then introduced into a platinum boiler, 5, which contains boiling nitric acid of specific gravity 1·26, in which it is allowed to remain for 15 minutes; it is then transferred to a similar boiler with acid of specific gravity 1·31. The silver is removed by the action of the acid, and the gold remains in a spongy state (H).

5th Process.—The gold sponge (which retains the original form of the cornet) is rendered coherent by annealing at a dull red heat. This is accomplished by introducing the platinum tray into the muffle. The cornets then assume the appearance of (I).

6th Process.—The final operation consists in weighing the cornets. This is done in a specially constructed "assay" balance, 6, which is capable of indicating about $\frac{1}{3000}$th of a grain when loaded with 7·5 grains in each pan. The weights employed bear a decimal relation to the original weight of the piece of metal operated upon. The percentage of gold, therefore, present in the alloy, is at once indicated without calculation. The weighing in the first process was of course conducted on the same or a similar balance.

2771. Appliances used in the Assay of Silver.

1. Pipette for "standard" salt solution used in silver assaying.
2. Pipette for "decimal" salt solution.
3. Riemsdijk's apparatus for adding drops of decimal solution.

The Master of the Mint.

The assay of silver can be conducted by cupellation, an operation similar to that already described in the 2nd process of the assay of gold, the only differences being that no pure silver is added to the assay piece, and the operation terminates when the button (D) has been obtained and weighed. The wet method of Gay Lussac is, however, now usually employed for the assay of silver when the "standard" is approximately known, and the alloy contains not less than 50 per cent. of silver. It consists in precipitating the precious metal from the solution of a known weight of the alloy to be assayed, the weight being so adjusted that sufficient silver is present to neutralize a given volume of the solution employed as a precipitant. This solution is usually one of common salt, but hydrochloric acid or hydrobromic acid may sometimes be used with advantage. The assay pieces, having been carefully weighed, are placed in numbered bottles, and a definite amount of moderately dilute nitric acid is added to each, the bottles being then moderately heated to assist solution. The standard solution is then carefully introduced by means of a pipette, and the bottles are vigorously shaken until the precipitate coheres and the solution becomes clear. A cubic centimetre of "decimal" solution, which is $\frac{1}{10}$th as strong as the "standard" solution, is then added to each bottle, and they are again shaken. This is repeated until the decimal solution produces either no cloud or a very slight one. This indicates the conclusion of the operation, as the amount of silver present can be calculated when the weight of salt which is required to saturate it is known.

From the above description it will be seen that the only special apparatus required in assaying silver by the method of Gay Lussac is a pipette for measuring out the "standard" solution, and one for adding "decimal" solution. 1 and 2 are the forms of these used in the Royal Mint. The pipette for standard solution, 1, is fixed in a vertical position and filled by an india-rubber tube from below. The opening at the upper end of the pipette is closed by the finger, the india-rubber tube is removed, and the solution thus accurately measured is added to the contents of a bottle. No. 2 is divided into cubic centimetres, and the additions made by means of it as already described. When great accuracy is required the decimal solution may be added drop by drop by means of the apparatus No. 3, designed by Chevalier Van Riemsdijk, of the Utrecht Mint.

2415e. Appliances for testing Gold and Silver.

All these objects date from the time of the first quarter of the 18th century, and are the property of His Highness Prince Pless, of Fürstenstein Castle. *The Breslau Committee.*

2458. Gay Lussac's Apparatus for assaying Silver by the Wet Way. *Aug. Bel and Co.*

Copper cistern lined with resinous cement to contain the normal solution of salt, 100 standard measures of which correspond with 896-thousandth of fine silver in the assay. Funnel for use in filling the cistern. Pipette of 100 *cc*, for use with normal solution. Pipette for use with decimal salt solution. Pipette for use with the decimal silver solution. Cage for conveying the bottles to the shaking apparatus. Shaking apparatus, filled with 10 assay bottles in position for use. Dark case for bottle, containing the decimal silver solution. Case in which the assay bottle is placed during the addition of the normal solution to the assay. Hollow pillar, with sponge for absorbing the excess of liquid from the front pipette during the adjustment of the level to gauge mark. Water bath used for heating assay bottles during the solution of assay pieces. Bellows used for removing the nitrous fumes from the assay bottles. Whisk used for stirring the salt solution in the cistern.

2761. Chart with Photographs of an Assay-Balance for Buttons of a Weighing-out Assay-Balance and of a Blowing Apparatus. *C. Osterland, Freiberg, Saxony.*

The balances represented by the photographs have the columnar lifting apparatus constructed by the exhibitor, which not only allows of the beam being raised from the outside, but which renders the displacement of so light a beam impossible. Assay balances of this kind have been made by the exhibitor, which weigh to the 20th or 40th of a milligramme.

2762. Improved Furnace for Puddling Iron.

Jeremiah Head, M.Inst.C.E.

The object is to utilize a portion of the waste heat which ordinarily is discharged from the chimney, by causing it to heat air to be afterwards supplied for the combustion of the fuel. Part of the chimney is enlarged into a chamber, having a vertical partition extending nearly to the top. One half of the chamber thus divided contains a cast-iron stove pipe, and the other half is provided with a damper.

When the damper is withdrawn the heated products of combustion take the nearest route to the chimney, but when it is closed they are obliged to pass by the more circuitous route, heating the stove pipe on the way.

The air for combustion is injected, by means of a steam jet, into a funnel connected with one side of a divided box, upon which the stove pipe stands. Moistened with the steam it becomes a powerful absorber and radiator of heat. It passes through the heated stove pipe, and afterwards through the back of the furnace into a closed ash-pit, and a portion through tuyeres into the space above the fuel.

It has then attained a temperature of about 650 deg. Fahr. The consumption of coal of this furnace has averaged 12 cwt. 2 qrs. 11 lbs. per ton of puddled bar over two months of ordinary work, including lighting up and lost heats. This is about one half of the usual consumption of fuel. The iron (refined) used per ton of puddled bar in the same time averaged 20 cwt. 2 qrs. 26 lbs. The heating chamber is surmounted by a boiler, intended still further to utilize the waste heat. This, however, is not essential, and is hardly worth the extra expense. An ordinary iron-cased chimney is preferable.

1762a. Description of Revolving Puddling Furnace.
Thomas Russell Crampton.

The peculiarity of this revolving puddling furnace is that one chamber forms the gas producing, combustion, and working chamber, no separate fireplace, fire-bricks, or fire-bars being employed. The heat being produced without smoke by the automatic injection of powdered fuel and air into the chamber. The whole furnace is protected by water circulating between a double casing.

Puddle balls of wrought iron up to 30 cwt. can be produced in one mass without fatigue to the men; the puddling being effected by revolving the furnace mechanically.

2763. Models to illustrate Dr. C. William Siemens' processes for the production of wrought iron from iron ore, and of cast steel, in large quantities.

No. 1. Regenerative Gas Rotative Furnace, from which wrought iron is obtained from iron ores mixed with fluxing and carbonaceous materials by a direct process. The puddled balls thus made may either be shingled and treated for the production of wrought iron, or be transferred to a steel melting furnace for the production of cast steel.

2. Regenerative Gas Furnace for the production of cast steel in large quantities on the open hearth, from pig iron, puddled blooms, iron or steel scrap, and iron ore.
Geological Museum, Jermyn Street.

2764a. Whitwell's Fire-brick Hot Blast Stove or Oven, as specially designed for heating the blast for blast furnaces.
Thomas Whitwell.

This model, to the scale of 1 inch to 1 foot, represents a stove 22 feet diameter × 28′ 6″ high, capable of heating 8,000 cubic feet of air per minute to a temperature of 1,400–1,450° Fah. during 60 consecutive minutes, after which it is again re-heated by the furnace gases, the combustion and absorption being so perfect that the products of combustion pass off to the chimney at a temperature of 250° Fah. only. These stoves are largely adapted to furnaces making Bessemer pig iron direct, also for anthracite fuel, and the various qualities of charcoal iron, Cleveland, spathic, spiegeleisen, &c.

The stoves are made of different dimensions to suit situation, but cost from 350*l.* upwards, according to size. Four stoves to the scale of the model make 500 tons a week of Bessemer iron with 19 cwt. of coke to the ton of iron. There is no loss of pressure by friction or loss of blast by leakage, and they require only two-thirds the quantity of gas that the ordinary cast-iron pipe system demands.

2764b. Set of Drawings of two Blast Furnaces, erected at Middlesbrough by Messrs. B. Samuelson and Co., together with the requisite heating stoves, kilns for calcining ironstone, blowing engines, &c. &c. *Bernhard Samuelson, M.P.*

The peculiarity is in the large dimensions of the blast furnaces (height from bottom of hearth to charging plate, 85 feet; diameter of bosh, 28 feet), resulting in a great economy of fuel; so that after they have been in blast nearly six years the quantity of coke required to produce a ton of No. 1 or 3 foundry pig iron is on the average less than 22 cwt.

2767. Sections of **Steel Ingots,** one cast in the ordinary way, the other compressed while in a fluid state.

Sir Joseph Whitworth & Co., Limited.

By the ordinary method of manufacture, it is found to be impossible to produce sound ductile steel suitable for constructive purposes, owing to the presence of honey-combed air-cells, which are altogether uncertain in their size and situation, and undiscoverable until laid bare by fracture or sections.

By compressing the metal while in a fluid state this defect is overcome, and a sound trustworthy material produced. This is shown by the two ingots, one cast in the ordinary way, and the other compressed while fluid.

2765. Tubes tested with **Gunpowder,** to show the strength and ductility of Whitworth fluid compressed steel.

Sir Joseph Whitworth & Co., Limited.

These tubes were tested to ascertain the strength and ductility of fluid compressed steel, as made for guns, torpedoes, &c.

The ductility is shown by the metal bulging under the strain, instead of flying in pieces.

2766. Sample Pieces of **Metal,** used for testing, to ascertain the strength and ductility of metal.

Sir Joseph Whitworth & Co., Limited.

There is no scientific line of demarcation between iron and steel. Sir Joseph Whitworth proposes that such a line should be established, and that the quality of a metal should be represented by two numbers, showing its strength and ductility.

These test pieces are similar to those in use by Sir Joseph Whitworth in testing his fluid compressed steel, to ascertain the proportions of strength and ductility which is required for different purposes.

The greater the strength, and the greater the ductility, the higher the quality of the metal.

2767a. Sample of Iron melted by means of compressed air.

M. Enfir fils, Paris.

2769. Set of cubical specimens of **Coal, Ironstone, Limestone,** and **Cold Blast Iron.** Illustrating the exact proportions, both in weight and bulk, of the minerals, coal, ironstone, and limestone, consumed in the blast furnaces for the production one cubic inch of cast iron at the Bowling Ironworks.

The Bowling Iron Company, Limited.

The coal is coked and the ironstone calcined preparatory to their introduction into the blast furnace.

2774. Diagram, illustrative of a Westphalian blast furnace of most recent construction, for the use of lecturers on metallurgy.

Prof. Dr. Dürre, Aix-la-Chapelle.

2566c. Furnace for Melting Platinum, by Deville's method, with cover and jets. *Johnson, Matthey, and Co.*

Size in which 3,250 ounces troy (about 100 kilos.) is melted in one charge.

2775a. Saturn Steel. *M. Breguet, Paris.*

2775. Diagram, illustrative of a lead smelting furnace on Pilz's principle, for the use of lecturers on metallurgy.

Prof. Dr. Dürre, Aix-la-Chapelle.

These diagrams are drawn to scale, and can also be employed for teaching constructive drawing and as designs for smelting works.

2415d. Seven different metal Wires of equal Strength and Weight, for determining the Specific Gravity from their length, by means of a scale.

The Breslau Committee.

VIII.–MODELS, DIAGRAMS, APPARATUS, AND CHEMICALS USED IN TEACHING CHEMISTRY.

2444. Series of ½-inch cardboard cubes, with different colour for each chemical element on which its symbol, atomicity, and combining weight are marked, illustrating the laws of chemical combination and the binary theory of Salts.

Rev. Nicholas Brady, M.A.

Only a comparatively small number are sent, as they will sufficiently show their method of use, thus $\begin{array}{|c|c|c|}\hline \mathrm{H} & \mathrm{H} & \mathrm{O} \\ {\scriptstyle 1} & {\scriptstyle 1} & {\scriptstyle 1} \\ \hline\end{array}$ represents the molecule of water, the dyad oxygen requiring two monads to satisfy it, the chemical equivalent of the compound being $1+1+16=18$.

2445. Lecture-Room Diagrams of Alkali Works and Sulphuric Acid Plant. In 4 sheets. *Prof. Roscoe, F.R.S.*

I.—*Sulphuric Acid Plant.*

Sheet No. 1. General plan, showing the arrangement of the most modern form of sulphuric acid plant, drawn to scale, with descriptions.

Sheet No. 2 contains a longitudinal section of the apparatus and chambers on the line C D, sheet No. 1.

Sheet No. 3 contains a sectional elevation of the same apparatus on the line A B, sheet No. 1.

Details on sheet No. 2 and sheet No. 3 show various points of importance on an enlarged scale.

No less than 850,000 tons of sulphuric acid were made last year in Great Britain. The diagrams show the most approved method for the manufacture of this important acid, together with the best arrangement of the plant, and are so fully numbered and explained that further description appears unnecessary.

II. *Alkali Works.*

Sheet No. 4 is an enlarged plan of a model alkali works, showing the best arrangement of the various portions of the works; also fully lettered and numbered. As in the above case a description appears unnecessary.

2442. Drawings, two, illustrating the making of coal-gas, used for teaching chemistry in the Secondary Schools.

I. Coal-gas factory.
II. Regulator of coal-gas factory.

Dr. D. de Loos, Director of the Secondary Town School, Leyden.

2452. Model of the Chemical Laboratory of the Secondary Town School, Leyden. Constructed by J. Noest, custodian of the building.

Dr. D. de Loos, Lecturer on Chemistry, and Director of the Secondary Town School, Leyden.

A. Forcing-pump. The pump fills a large cistern in the upper part of the building. This cistern discharges its contents into the *white* pipes, and supplies the laboratory and the other parts of the building with water. The *red* pipes carry off the drainage from the laboratory into a sink constructed below the surface. The large *black* pipes, as also the small ones over the pupils' work-tables, are the gaspipes.

B. Register-school.

C. Chimney with three passages; one to conduct off the smoke of the stove, the others to carry off the bad gases disengaged in chemical operations.

D. Pump for rain-water and well-water.

E. Cupboards for twenty-two pupils, in which they keep the re-agents; the largest, which is open, is for the use of the lecturer on chemistry.

F. Drawer for small apparatus, as spoons, glass tubes, &c.

G. Small cupboards for the use of the pupils, in which to keep chemical preparations still in progress.

H. Bunsen's pump to filter under a lesser pressure. The water, running through the red pipe from the top to the bottom of the laboratory, carries the air from the bottle along with it.

I. Entrance to the balance-room.

K. Collection of implements for performing chemical experiments.

L. Large cupboard for chemical preparations and apparatus.

M. Table with apparatus for blowing glass.

2455b. Case containing five stands and a collection of spheres made to **demonstrate** the **structure of chemical combinations** according to the theories of A. W. Hofmann.

Manuel Gonzalez, Madrid.

2453. Diagram of Carre's Ice-making Machine, by Mr. Hubertus Sattler. *Dr. Alexander Bauer, Vienna.*

Adapted to be used for making experiments at lectures on technical chemistry to small audiences.

2408. Apparatus for exhibiting in the lecture room the contraction which takes place when oxygen is changed into ozone. It is a modified Siemens' tube; the contraction being shown by the ascent of the sulphuric acid in which the open end of the tube is immersed. *Dr. Andrews, F.R.S*

2575. Filtering Apparatus, provided with a glass receiver and 2 india-rubber rings and supports.

F. A. Wolff & Sons, Heilbronn and Vienna.

This filtering apparatus is intended for the use of schools.

2456h. Cavendish's Eudiometer. *E. Cetti & Co.*

2575a. Model and Section of Spongy Iron Filter, with filtering materials employed. *Gustav Bischof.*

Spongy iron is metallic iron in a spongy or porous state, obtained by the reduction of an oxide without fusion. The powerful property of metallic iron to purify water has been known for a long time, but its application in the spongy state only renders the purification sufficiently rapid to be of practical use. The water in passing through the spongy iron dissolves a minute quantity of iron, which is completely retained by a mixture of sand and pyrolusite underneath.

Pyrolusite has the property of converting protosalts of iron into persalts. The latter are again decomposed, probably by the agency of calcic carbonate in water, and the ferric hydrate formed is mechanically retained by the sand. Ammonia and other substances are likewise oxidised by pyrolusite.

The hardness of water is very considerably reduced, and every trace of lead removed by filtration through the spongy iron filter. (See VI. Report of the Royal Commission on Rivers Pollution, 1875, pp. 220, 221; Report of the Registrar General, 8th January 1876; Journal of the Royal Agricultural Society of England, Vol. XI., part I., 1875, p. 158.)

A small lateral opening in the regulator tube forms the only communication between the upper part of the filter and the reservoir for filtered water. The flow of the water is thus completely controlled by the size of such opening to ensure a sufficient contact between the purifying medium and the water.

2455a. Apparatus for showing the **Decomposition** of **Steam** by the **Heat** of **Electric Sparks.**

Prof. Frankland, F.R.S.

SECTION 14.—METEOROLOGY.

WEST GALLERY, GROUND FLOOR, ROOM L.

I.—SPECIAL COLLECTIONS.

METEOROLOGICAL INSTRUMENTS, A SET AS LENT TO CAPTAINS OF MERCHANT SHIPS, COMPRISING :—

2776. Board of Trade Marine Barometer, Kew pattern ; the best barometer yet devised for use at sea, serviceable also as a station barometer; by Adie, marked B.T. 12 ; certificate of Kew verification in box.

2777. Board of Trade Marine Thermometers. Set of six, Kew pattern ; one for sea-water, in copper case, one for air, and one for evaporation temperatures, with three spare to replace breakages ; by Casella, marked B.T. 1720 to 1725 ; certificate of Kew verifications in box.

2778. Board of Trade Thermometer Screen, for "dry-bulb" and "wet-bulb" thermometers, with water-cup. For use on ship board.

2779. Board of Trade Marine Hydrometers. Set of four; by Casella, marked B.T. 610, 620, 630 ; for testing the specific gravity of sea-water; by Hicks, A. 170, for the denser water of the Suez Canal ; certificate of Kew verifications in box.

2780. Board of Trade Prismatic Azimuth Compass, in box. This instrument is lent only in a few special cases.

2781. Meteorological Register, for observers using the above instruments at sea.

2782. Rough Register, for use at sea. The observations should be entered at the time of making them, and afterwards copied into the preceding register.

Meteorological Committee of the Royal Society.

2783. Equipment of a Second Order Station, approved by the METEOROLOGICAL SOCIETY, consisting of the following instruments :—

STANDARD BAROMETER.

THERMOMETER STAND, containing DRY BULB THERMOMETER, WET BULB THERMOMETER, MAXIMUM THERMOMETER, and MINIMUM THERMOMETER.

RAIN GAUGE.

BLACK and BRIGHT BULB THERMOMETERS *in vacuo*, for determining the intensity of solar radiation.

MINIMUM THERMOMETER for determining the intensity of terrestrial radiation.

ANEMOMETER.

With specimen forms, instructions for taking, and tables for reducing, the observations.

Publications of the Meteorological Society :—

Quarterly Journal, Vols. I. and II., 1872–1875.
List of Fellows, January 31st, 1876.
Catalogue of the Library, revised to December 31st, 1875.
Instructions for the observation of phenological phenomena, charter, and byelaws. *Meteorological Society.*

2784. Instruments used at the Russian Meteorological Stations. A specimen set.

Wild's adjustable syphon barometer, No. 45, with screw for suspension and key for valve.

Three thermometers by Geisler, dry bulb and wet bulb, No. 244, minimum No. 138.

Thermometer-screen, No. 141, made of zinc, to revolve round its vertical axis, carrying the above thermometers.

Saussure's hair hygrometer, No. 9, in box.

Russian rain and snow gauge, with glass measure, &c., No. 118.

Wild's anemometer on iron swinging plate, for observing direction and pressure of wind.

Meteorological Committee of the Royal Society.

2786. Meteorological Instruments, made under the direction of the late Sir John Leslie, and used by him.

Scottish Meteorological Society.

1. Portable Hygrometer (with specimen of Sir J. Leslie's writing).
2. Stationary Hygrometer.

The covered ball in both cases being wetted and exposed to evaporation, the liquor soon marks, by its descent in the opposite stem, the dryness of the air.

3. Leslie's Atmometer. It consists of a ball of thin porous earthenware, to which is cemented a wide glass tube, bearing divisions which correspond each to the measure of a film of water that would cover the external surface to the thickness of the thousandth part of an inch.

1. Two volumes of the Society's Quarterly Reports from 1856 to 1863.
2. Vols. I., II., III., and IV. of the Society's Journal from 1863 to present date.
3. Three Papers by A. Buchan, Secretary, from Trans. Roy. Soc. Edin. *Scottish Meteorological Society.*

2787. Meteorological Instruments, set, for the use of colleges and public schools. *Francis Pastorelli.*

These instruments when compared with the standards at the Kew Observatory will be found to be within the error permitted by that institution.

They consist of a comparative standard barometer, maximum and minimum thermometer, wet and dry bulb hygrometer, terrestrial radiation thermometer, solar radiation (in vacuo) thermometer, rain gauge and graduated measure.

2788a. Special set of Observatory Standard Meteorological Instruments. Negretti and Zambra's special selection of standard meteorological instruments for a first class observatory station, consisting of :—Standard barometer, Negretti and Zambra's patent maximum thermometer, Rutherford's minimum thermometer, Negretti and Zambra's patent mercurial minimum thermometer, hygrometer, wet and dry bulb, Negretti and Zambra's patent solar radiation thermometer, terrestrial radiation thermometer, Robinson's anemometer, rain-gauge (Glaisher's pattern). *Negretti and Zambra.*

2788. Specimens of Meteorological Instruments, supplied by the Meteorological Office to the Royal Navy :—

Kew-pattern Marine Barometer, iron cistern, tube protected with India-rubber packing against damage by concussion from gun-firing, &c. ; by Adie, marked A 430 ; certificate of Kew verification in box. Glass tube and packing, as fitted to the above barometer.

Pair of Thermometers, maximum ↑ A 369, and minimum ↑ A 394 ; constructed specially for use at sea in chronometer-rooms, by Hicks. Certificates of verification in box.

Aneroid, compensated for temperature, marked Elliott, A 421.

N.B. The thermometers, screen, and hydrometers supplied to Her Majesty's ships are of the same pattern as those lent to merchant ships, Nos. 2777–79.

Portable Instruments used by Admiralty Surveyors: Pocket Aneroid, compensated, Casella, ↑ 6 (548).

Pocket Thermometer, mounted in boxwood, in leather case, Casella, No. 13.

Portable thermometer (thermometre fronde), in padded tin case, Hicks, B. T. 499 ; to give the temperature of the air when whirled round at the end of a string. *Meteorological Committee.*

2789. Specimens of Instruments used at Stations of the Meteorological Office :—

Barometer, used at Coast Stations as a weather-glass, by Hicks, M. O. 143.

Stevenson's Thermometer Screen, by Hicks.

Maximum Thermometer, by Negretti and Zambra, B. T. 215 (5577).

Minimum Ditto, B. T. 216 (10,435) ; certificates of verification in boxes.

Copper Rain, and Snow Gauge, Can, and Glass, by Casella, M. O. 150.

Solar Radiation Thermometer, in vacuo ; Negretti's Maximum, with platinum points for testing, Hicks, M. O. 10.

Terrestrial Radiation Thermometer, with hollow bulb for sensitiveness, Hicks, 18,429. *Meteorological Committee.*

2789a. Milne's Barograph, by West, clockwork by Schoof. *Meteorological Office.*

2789b. Portable Barometer, graduated on the glass tube, with a sliding vernier, invented and used by Sir John Richardson, M.D., F.R.S., in his expeditions in North America. *Meteorological Office.*

2789c. French Station Barometer, by Tonnelot, J.G. 48, cistern of large diameter to diminish capacity error. *Meteorological Office.*

2789d. Von Lamont's Atmometer. *Meteorological Office.*

2789e. Wall Screen, for registering thermometers. *Meteorological Office.*

2789f. Tube, Lath, and Thermometer, by Hicks A 164, for taking earth temperatures. *Meteorological Office.*

2789g. Hypsometer Apparatus, as improved by Dr. G. Henderson, with two maximum thermometers, by Hicks, 39621, 39622, in leather sling-case, with certificates. *Meteorological Office.*

2789h. Johnson's Deep-sea Pressure Gauge, ↑ 1, with box. *Meteorological Office.*

2789i. Deep-sea Thermometers :—

Johnson's metallic, ↑ 6.

Negretti's protected bulb, ↑ 9.

Casella's protected bulb, 21260, with certificate.

Elliott's unprotected, with certificate, ↑ 36.

Pastorelli's unprotected, No. 5, out of order, used by Sir J. C. Ross. Notwithstanding the thickness of the glass a similar instrument to this rose 9·2°, under a pressure of two tons on the square inch. *Meteorological Office.*

2789k. Quarterly Journal of the Meteorological Society, Vols. I. and II., 1872 to 1875. *Meteorological Society.*

SET OF INSTRUMENTS made on the KEW PATTERN, by P. ADIE, for the PHYSICAL OBSERVATORY, at POTSDAM.

2789l. Magnetometer. *Dr. H. W. Vogel.*

2789m. Declination Magnetometer. *Dr. H. W. Vogel.*

2789n. Vertical Force Magnetometer. *Dr. H. W. Vogel.*

2789o. Automatic recording Apparatus. *Dr. H. W. Vogel.*

II.—BAROMETERS.

a. MERCURIAL.

2790. Large Standard Barometer, $\frac{7}{10}''$ tube, with English and metrical scales, glass plunger cistern, and pipette in tube for preservation of vacuum. *Patrick Adie.*

2791. Medium Standard Barometer, $\frac{5}{10}''$ tube, with glass plunger cistern, and pipette in tube for preservation of vacuum. As used in Government meteorological observations. *Patrick Adie.*

2792. Small Standard Barometer, with glass plunger cistern, and pipette in tube for preservation of vacuum. Medical Department, War Office pattern. *Patrick Adie.*

2793. Large Standard Barometer, with single readings. Kew Observatory verification, and pipette in tube for preservation of vacuum. Kew pattern. *Patrick Adie.*

2794. Medium Standard Barometer, with single readings, Kew Observatory verification, and pipette in tube for preservation of vacuum. Kew pattern. *Patrick Adie.*

2795. Mountain Barometer, Fortin's, on tripod, with pipette in tube for preservation of vacuum. *Patrick Adie.*

2796. Gay-Lussac's Portable Barometer, with pipette in tube for preservation of vacuum. *Patrick Adie.*

2796a. Standard Barometer with Electrical Adjustment. *Negretti and Zambra.*

This is a tube dipping into a glass cistern of mercury, fitted with a vertical adjustment screw. Through the top of the tube a platina wire is passed and hermetically sealed. The cistern has a metallic connexion, so that by means of copper wires (in the frame) a galvanic circuit is established; another connexion also exists by a metallic point dipping into the cistern. The circuit, however, can be cut off from this by means of a switch placed about midway up the frame. On one side of the tube is placed a scale of inches, with a circular vernier, divided into 100 parts, connected with the dipping point and working at right angles with the scale.

2796b. Negretti and Zambra's Standard Barometer, constructed on Fortin's principle, proved to be the most reliable arrangement yet introduced. The level of the mercury in the cistern being adjusted previous to each observation to a fixed ivory zero-point, loss of mercury from leakage or oxidation is of little or no importance, and does not affect the accuracy of the readings. The tubes are of varying internal diameter, and are filled with pure mercury, very carefully boiled in the tube to perfectly expel all air or moisture. *Negretti and Zambra.*

2796c. The Gun Marine Barometer, constructed by Negretti and Zambra for special use in Her Majesty's navy, and now the adopted Admiralty pattern. It differs from barometers hitherto made by having its tube packed with vulcanised india-rubber, which checks vibration from concussion, thereby doing away with the necessity of unshipping the barometer during gun firing.

See Admiral Fitzroy's report, 9th number of the Meteorological Papers, issued by the Board of Trade. *Negretti and Zambra.*

2796d. Negretti and Zambra's Self-registering Mercurial Barometer. *Negretti and Zambra.*

In this instrument the various parts of the mechanism have been so arranged that the recording is effected by means of a clock, which causes a drum to revolve, carrying round it a paper. On this paper is traced the barometric curve by a pencil attached to a float, and placed on the mercury of a syphon barometer tube.

See Negretti and Zambra's Treatise on Meteorological Instruments.

2796e. Howson's Patent Long Range Barometer. *Negretti and Zambra.*

In this barometer the tube is fixed, but its cistern is sustained by the upward pressure of the atmosphere. Looking at the instrument it appears as though the cistern with mercury in it must fall to the ground. The bore of the tube is about an inch across. A long glass rod is fixed to the bottom of the cistern. The tube being filled with mercury, the glass rod is plunged into the tube as it is held upside down, and when it is inverted the mercury partly falls and forms an ordinary barometric column. The cistern and glass rod, instead of falling away, remains suspended. There is no material support to the cistern; the tube only is fixed, the cistern hangs to it. The glass rod, being so much lighter than mercury, floats and sustains the additional weight of the cistern by its buoyancy, and the almosphere acting on the mercury keeps up the barometric column.

2796f. Long Range Barometer. *Negretti and Zambra.*

This instrument consists of a mercurial tube on the syphon principle, one side of the syphon, the closed end, being about 33½ inches long, and the other only a few inches in length. To this short end or leg is joined a length of glass tubing of a much smaller (internal) diameter, both legs being of equal length; the smaller tube is filled with a fluid many times lighter in specific gravity than mercury, the rising and falling of the mercurial column in the large tube having a lighter fluid to balance, and that dispersed over a larger space by reason of the difference in the diameter of the two tubes, a longer range is obtained due both to the unequal capacity of the two tubes and the difference in the specific gravity of the mercury and the second fluid employed. The range of these barometers is from 6 to 10 inches to the inch of the ordinary mercurial barometer; the $\frac{1}{100}$th of an inch can easily be observed without the use of a vernier.

It is a most interesting instrument, as from the extremely extended scale the slightest variation is plainly visible.

Large Household Barometer, for ordinary use.
Negretti and Zambra.

Domestic Standard Barometer, of the same construction as 2796*b*, but of smaller size. *Negretti and Zambra.*

2797. Mercurial Barometer, an old Dutch instrument by Reballio, combining syphon and long range barometer, thermometer, and hygrometer. *Pillischer.*

2798. Drawing of a "Balance" Barometer, of which a model was executed, submitted to the Royal Irish Academy, and tested during some months. *Jos. P. O'Reilly.*

The column is inclined from the vertical, and suspended by a knife edge, as the beam of a balance, whence the proposed name. The displacement of the mercury in the column causes this to incline more or less from the vertical, the amplitude of movement showing itself on a graduated limb by means of an index. The mode of action and the degree of sensitiveness of the instrument are therefore comparable to those of a beam balance, and the indications given without the intervention of wheel work.

2799. Barometer of De Luc, formerly belonging to **H. B. de Saussure,** and carried with him in his Alpine excursions.
H. de Saussure, Geneva.

2800. Meteorological Barometer by Wild, used in all meteorological stations throughout Russia.
Geneva Association for the Construction of Scientific Instruments.

This barometer is a combination of Fortin's barometer, and Gay-Lussac's old siphon barometer. For minute description, see "Mélanges physiques et chimiques, tirés du Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg," vol. ix, 23rd September to 5th October 1875.

2800a. Barometer of a New System of Construction.
W. Gloukhoff, Ministry of Finance, St. Petersburg.

For taking an observation with this barometer, the mercury of the cistern is forced to pass by means of the screw *A* through the hole *a* into the open space *m n*, formed by a glass ring, and to cover its bottom. Then the movable scale of the barometer is lowered so as to bring the steel end *C* of the scale near the surface of the mercury. Finally, by the screw *A* the surface of the mercury is made to touch the end *C* of the scale. The last part of the observation is made in the usual way.

2800b. Drawing of a **Normal Barometer** and **Manometer** of the Central Physical Laboratory, St. Petersburg, after the design of Wild, constructed by Brauer, St. Petersburg.

Dr. H. Wild, Director of Central Physical Observatory, St. Petersburg.

2800c. Drawing of a **Balance Barograph,** with temperature compensation according to a design by Wild, constructed by Hasler, Berne (Switzerland), registering by electricity every ten minutes.

Dr. H. Wild, Director of Central Physical Observatory, St. Petersburg.

2801. Stevenson's Portable Iron Barometer, with Mr. Sang's improvements. *Scottish Meteorological Society.*

All the stop-cocks being open, and the plug at lower limb out, fill in mercury till it begins to escape at this opening, shut stop-cock of lower limb, and fill to above upper stop cock of upper limb; shut both stop-cocks of longer limb, put in the plug and open stop-cock at lower limb. The float should then show the true reading as compared with a standard instrument. In this way a reading can always be obtained at the most inaccessible stations as accurately as when the instrument left the maker's hand. Designed by T. Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Society's Journal, Vol. iv, p. 265.

2801a. Capt. George's Improved Patent Mercurial Barometer for travelling. *Henry Porter.*

This process of filling by the spiral cord enables the traveller to fill the tube, and produce a perfect vacuum in about 15 minutes, and when the observation is registered the mercury is returned to its iron bottle and the *empty* tube returned to its packing of india-rubber and brass tube, so that it can be carried over the roughest country in perfect safety.

Hicks's Patent Flexible Mountain Barometer.

J. J. Hicks.

It consists of a flat bulb of flexible glass filled with mercury exhausted of all air and hermetically sealed at both ends. The inches are divided on the glass tube itself, which is mounted on a metal scale with small attached thermometer and sliding scale to compensate for temperature.

2802. Mercurial Barometer; may be rendered entirely void of air in half an hour without boiling.

Prof. Dr. Bohn, Aschaffenburg.

The instrument is easily constructed, even by persons without special training, at the place of observation itself. It is thus well adapted for transport. Permits controlling of the vacuum and avoids the errors of capillarity. No boiling of the mercury is required, and thus no loss of the graduated tubes is risked. The expense of constructing the instrument is very small.

2803. Barometer with movable bottom, Kupfer's method, improved by Köppen; constructed by Fuess, Berlin.

Imperial Admiralty Hydrographical Bureau, Berlin, and Deutsche Seewarte, Hamburg.

Instruments of this kind will in future be used as normal barometers in the meteorological system of the Naval Observatory.

2804. Glycerine Barometer. *Jas. B. Jordan.*

This instrument is designed for the purpose of affording a delicate "weather glass," indicating small changes of pressure by large oscillations of a fluid column, at the same time preserving all the accuracy of the mercurial barometer. The fluid used is glycerine, in a maximum state of purity, which has a specific gravity of 1·26, or about one tenth that of mercury. It has the advantage of giving a vapour of very low tension in the Torricellian vacuum from its high boiling point, and is therefore free from the masking effect of back pressure which interferes with the indications of a water barometer. The fluctuations of the column are observed in a glass tube of 1 inch sectional area, or 100th that of the cistern. The tube forming the body of the instrument is an ordinary composition gas pipe, $\frac{5}{8}$ inches diameter, 27 feet long, placed in the well of the staircase, between the upper and lower galleries. The exposed surface of the glycerine in the cistern is protected by a layer of paraffin oil, in order to prevent absorption of moisture.

The divided scale on the right hand side is in inches and tenths in absolute measure, while that on the left shows the equivalent values reduced to a column of mercury.

Instruments of this class can be constructed in the most simple form and at a moderate cost, and for museums and public institutions would be of great interest.

2805. Compensated Barometer.

Prof. Dr. A. Krueger, Helsingfors.

The upper part of the tube is enlarged to a retort, the volume of which corresponds to a length of one or two metres of the tube. A quantity of air is introduced into the tube, the pressure of which is equal to about $34\cdot5^{mm}$ mercury. The scale is divided with due regard to the effect of that depression. The zero having been adjusted by comparison with a standard barometer the reading will immediately give the barometer height reduced to normal temperature of mercury and scale. One millimetre of the scale $= \dfrac{1^{mm}}{\frac{P+p}{P} + \frac{34\cdot5}{\lambda}}$, p being the area of the tube, P of the cistern, and $p.\lambda$ the volume of the upper part above $725\cdot5^{mm}$ from the level in the cistern. An instrument of this construction has been in use some years at the Helsingfors Observatory.

2806. Standard Barometer, mounted in metal frame, with glass cistern, and pointed for adjusting the mercury before an observation is taken. *Elliott Brothers.*

2807. Diagonal Barometer invented by Sir Samuel Moreland, and made by T. Whitehurst, of Derby, 1772.

The Committee, Royal Museum, Peel Park, Salford.

The action of this form of barometer is explained in Rees' Cyclopedia, vol. 3., 1st edit., 1819.

2807a. Anerora or Mercurial Barometer, suitable for public buildings, at seaports, &c. Diameter of the dial, 1½ metre.

M. Redier, Paris.

2807b. Antique Baroscope. *G. J. Symons.*

2807c. Two Mountain Barometers (old forms).

G. J. Symons.

2808. Standard Metal Marine Barometer, Board of Trade pattern, as supplied to H.M. ships of war.

Francis Pastorelli.

The frame and cistern are of metal, bronzed, suspended by gymbals and a spring metal arm; it has a rotary motion to obtain the best light for observation. The barometer scale is divided to inches, tenths and 0·05 of an inch, the vernier, by means of a rack and pinion, works between two longitudinal openings; it reads direct to 0·002 of an inch, and by estimation to 0·001. The divided portion of the brass tube is protected from dust and moisture by a glass shield; the barometer tube is surrounded and packed by india-rubber to resist breakage by the discharge of heavy guns.

The barometer tube is made with a glass air-trap (a small portion of air ascending to the top of the tube would cause a great and variable error); this prevents the air from passing up to the top of the tube, which might occasionally happen with the barometer in careless usage. The interior diameter of the tube is about 0·35 of an inch. The mercury is carefully boiled in the tube to expel all particles of air and moisture. It is so contracted that an inch fall of mercury occupies four minutes of time; this is to prevent the oscillation of the mercury by the ship's motion. The scale divisions are corrected so that the error arising from the displacement of the zero by a rise or fall of the mercury in the cistern does not cause an error (in a well made barometer) of more than 0·008 of an inch.

2808a. Pastorelli's Mountain Barometer, in metal frame, similar in form to the Comparative Standard Barometer, specially designed for the use of civil engineers and scientific travellers.

F. Pastorelli.

Its great portability may be judged from the fact that its weight does not exceed 1½ lbs. Another very great advantage is that it cannot be deranged by careless use. The greatest error in this instrument rarely exceeds ·008 in. throughout its scale. It can be confidently recommended to engineers for a preliminary survey where greater accuracy is required than can be attained by use of the aneroid.

2809. Standard Barometer, upon Fortin's principle.

Francis Pastorelli.

The barometer tube is enclosed in a brass frame; connected with the tube is a glass cistern, which is fixed by three pillars, the ends of which have screws passing through an upper and lower brass plate, by means of which the necessary pressure can be applied to make it mercury-tight; at the bottom of the cistern is a leather bag, which is raised or lowered by an adjusting screw, permitting the surface of the mercury to be brought into perfect contact with a piece of ivory which forms the zero of the scale; this point is seen through the glass cistern. The vernier works between two longitudinal openings; it is moved by a rack and pinion, so that it may be adjusted to the apex of the surface of the mercurial column, and it is divided to read to the 0·002 of an inch, and by estimation to the ·001 of an inch; it can be divided to read directly to ·001 of an inch, but in that case the use of a magnifying glass or microscope is indispensable. The thermometer has the divisions etched upon the stem; it is fixed on the brass frame nearly in contact with the mercury tube. The barometer is suspended from a bracket fixed to a mahogany board, having a lower bracket with adjusting screws to fix it in a truly vertical position. The instrument permits of a rotary motion, in order to obtain the best light for observation. The internal diameter of the tube of this barometer is ·44 of an inch; the mercury is carefully boiled in the tube in order to insure the expulsion of all particles of air or moisture.

2809a. Carved Oak Barometer. *E. Cetti & Co.*

2809b. Small Pocket Standard Marriotte Barometer, Macneill's Patent, combining in itself nearly equal portability with the aneroid, and the constant correctness of the standard barometer, its action depending on the well-known laws of Marriotte and Boyle applied to the expansion and compression of air. *L. Casella.*

2809c. First Barometer, with weights, by Conté. Used in the expedition of Egypt.
Conservatoire des Arts et Métiers, Paris.

2809d. Barometer, with overfall. Constructed by Meynie for Lavoisier. *Conservatoire des Arts et Métiers, Paris.*

2809e. Skeleton of Construction of the Largest Barometers for Public Buildings. (For demonstrating purposes.)
M. Richard, Paris.

2809e. Metal Barometer.
Dr. Wilhelm Tinter, Professor of Practical Geometry at the I. R. Polytechnic Institute, Vienna.

2809f. Metal Barometer, of great sensitiveness (diameter, $0\cdot20^{m}$), of which the index describes a complete circle, under a differential pressure of one millimetre of mercury.
M. Richard, Paris.

2809g. Metal Barometer, for measuring heights (diameter, $0\cdot14^{m}$), of which the index describes a complete circle, by a difference of pressure of one centimetre of mercury.
M. Richard, Paris.

2809h. Aerostatic Barometer, with equal divisions, the index of which describes a complete circle, by a difference of pressure of one decimetre of mercury. *M. Richard, Paris.*

b. ANEROIDS.

2810. Aneroid Barometer. The ends of the axle which carries the index hand are jewelled like the pivots of a watch, and the hand works under the cap. By this means greater sensitiveness and especially greater definiteness of the indications are obtained. This aneroid will show a difference in height of 2 feet. *The Hon. Ralph Abercromby.*

2811. Aneroid Barometer, capable of measuring up to 5,000 metres from the level of the sea. With case, tables of comparisons, instructions, &c. *J. Goldschmid, Zürich.*

2812. Aneroid Barometer, capable of measuring from 9,000 to 10,000 metres from the sea level. With case, tables, and instructions, &c. *J. Goldschmid, Zürich.*

2813. Pocket Aneroid Barometer, of German silver. With case and instructions, &c. *J. Goldschmid, Zürich.*

2814. Aneroid Barometer, Weilenmann system. With tables. *J. Goldschmid, Zürich.*

2815. Aneroid Barometer, capable of measuring up to 5,000 metres. With tables, &c. *J. Goldschmid, Zürich.*

The faces of the above aneroid barometers are of German silver. The variations of reading are measured by a fine micrometer. A table, specially prepared, accompanies each instrument, and gives the height of the barometer. The correction for temperature, given in a second table, is founded on the observation of a small thermometer applied to the instrument.

2816. Miniature Aneroid Barometer, the dial measuring $\frac{5}{8}$ inch, the case $\frac{6}{8}$ inch in diameter, the bearings set in jewelled centres, compensated for temperature. *Pillischer.*

This is believed by the maker to be the smallest instrument of the kind ever constructed.

2816a. Pocket and Watch-sized Aneroid Barometers. *Negretti and Zambra.*

The patent for the aneroid having expired, the late Admiral Fitzroy urged upon Negretti and Zambra the desirability of reducing its size as well as improving its mechanical arrangement, and compensating it for temperature. They after great labour and numerous experiments, succeeded in reducing the dimensions to less than three inches in diameter and two inches in thickness. These instruments have since been further reduced by Negretti and Zambra, until they have at last reached the dimensions of an ordinary watch. These very small instruments are found to act quite as correctly as the largest, and are much more convenient; they may be had with a range sufficient to measure heights of 20,000 feet, with a scale of elevation in feet, as well as of pressure in inches.

2817. Two Aneroid Barometers, exhibitor's construction, with visible movement. *R. Deutschbein, Hamburg.*

2818. Two Metal Barometers, exhibitor's construction, with visible movement. *R. Deutschbein, Hamburg.*

2819. Two Spring Barometers, exhibitor's construction, with visible movement. *R. Deutschbein, Hamburg.*

The first four are house barometers, distinguished by good workmanship, shape, and cheapness. The last two instruments are spring barometers, specially adapted to meteorological observations, determination of heights, &c.

The aneroid barometers of the Reitz system are metal barometers with a vacuum box according to Vidi. The movements of the box are read off by means of a microscope on a scale which is divided into hundredths of millimètres. Each degree can easily be further subdivided by estimation into ten parts. One such tenth corresponds to about $\frac{1}{30}$ mm. of the mercurial column, or a difference in height of $\frac{1}{3}$ meter.

The instrument is chiefly destined for the preparatory tracings of railway lines and similar engineering works, and also for the observation of minute oscillations in the atmospheric pressure. Its construction is considerably simpler than usual; optical means serve to magnify the movements of the vacuum box, instead of the customary transmission by lever; the instrument is easily handled in the field. Care has been taken in the correct application of the thermometer, which is to indicate the temperature of the most important parts of the instrument.

2820a. Field's Engineering Aneroid, with extra compensation for the temperature of the air. *L. Casella.*

2820b. Open Range Aneroid, with registering indices, most portable and convenient for showing the maximum and minimum pressure of the air. *L. Casella.*

2820c. Aneroid with Gold Band, for moist climates and coal mines. *L. Casella.*

2820d. Cary's Improved hardy Aneroid Barometer made strong expressly for the use of travellers, in improved wood and leather case and sling. *Henry Porter.*

2820e. Wheel Aneroid Barometer on stand. *G. Washington Moon.*

c. SYMPIESOMETERS.

2821. Sympiesometer, a sensitive instrument for sea use. *Francis Pastorelli.*

This consists of a syphon tube, containing a volume of air and a fixed fluid that partly fills the tube, also a thermometer. Its principle of action is upon Mariotte or Boyle's law. By an increase or decrease of the weight of the atmosphere the fluid is raised or lowered (arising from the elasticity of the enclosed air), through equal distances for each barometric inch if the confined air were unaffected by varying heats, but as it is affected by temperature this error is allowed for by a temperature scale. To take a reading note first the temperature of the thermometer; now set the pointer attached to the movable scale of inches, by means of its rack motion, to the corresponding degrees of temperature of the syphon tube, the position of the fluid indicates the height of the barometer. This instrument is considered by many a most valuable instrument; it is more sensitive than the barometer, and when accurately constructed should give good results.

III.—SPECIAL THERMOMETERS.

2823. Old Floating Thermometer, by Gay Lussac and Collardeau, of Paris. *G. J. Symons.*

2824. Thermometer of Translation or Integrator of variations of temperature. *Scottish Meteorological Society.*

The bar of zinc is fixed at its lower end during expansion by the needle points catching in the teeth of the rack below, so as to produce lengthening upwards, while during contraction the bar is held by the needle at the top, so that the shrinking is upwards. In this way the centre of gravity is moved upwards. The total annual march or creep of the bar will measure the total amount of fluctuation of temperature. Designed by Thomas Stevenson, C.E., Honorary Secretary.

2825. Von Lamont's Terrestrial Thermometer, for determining the temperature of soil from one to four feet deep.

Prof. Ebermayer, Aschaffenburg.

2826. Three Vacuum Thermometers for studying solar radiation.

2826a. Six's Self-registering Thermometer, for registering the degree of heat and cold. *Francis Pastorelli.*

The thermometer is continuous; in form it appears as three parallel limbs, the interior of the central and shorter one is filled with a fluid, the other two limbs partly with the same fluid and mercury. Floating in the fluid in each of the outside limbs above the mercury are two registering indices; they consist of pieces of fine steel enclosed in delicate glass tubes. Attached to them are hair springs, which retain them in a fixed position, unless acted upon by a force. The force used to set them is a magnet.

2826c. Standard Maximum Thermometer with divisions on the tube, protected by a glass shield covering from the rain and action of the atmosphere; by this contrivance it retains its legible appearance. *Francis Pastorelli.*

2826d. Standard Minimum Thermometer. Wet and Dry Bulb Hygrometer; mounted on a vulcanite scale.

Francis Pastorelli.

The maximum is constructed upon the valve principle patented by Negretti and Zambra. This thermometer has in its bend near the ball a small piece of solid enamel glass partly fused; the ball and part of the stem are filled with mercury, the upper part is a vacuum, the piece of enamel glass acts as a valve, for by applying heat to the mercury ball, the mercury in expanding passes the enamel glass (but it cannot return on cooling), it registers the amount of heat applied, which is read at the upper end of the column.

To set this thermometer for a new observation hold the ball downwards in the hand, with a gentle shake the mercury in the tube will unite with that in the ball.

The minimum is upon Rutherford's principle. A small glass index floats in the spirit; its end farthest from the ball is flattened. To set the thermometer gently incline it with the ball uppermost, the index will then fall to the end of the film of spirit; place it in a horizontal position, as the temperature falls the index will be drawn back by the last film of spirit by attraction and there remain, the lowest point to which the spirit has receded; on an increase of temperature the spirit passes the index, it cannot move it.

2826e. Minimum Thermometer, with flat bulb.
Dring and Fage.

Constructed with a view to overcome the great drawback to the use of spirit thermometers, sluggishness. The bulb is made flat, so as to expose as large a surface as possible, while the glass is made as thin as is consistent with a non-barometric action.

2826f. Symons' Earth Thermometer. A portable arrangement for showing temperature at any depth, divested of the risk and difficulty of using the long and awkward thermometers hitherto employed for this purpose. *L. Casella.*

2822. Thermometers. The set of fourteen employed by the Exhibitor in experiments on the sensitiveness of thermometers. (Quarterly Journal Meteor. Soc., Vol. ii, p. 123.) *G. J. Symons.*

2827a. Plain Thermometer, Thermometer with Enamel Tube. *Negretti and Zambra.*

A plain and an enamel thermometer placed side by side, showing the immense advantage of the enamel over the plain. The extremely delicate investigations of medical and scientific men could not be carried on by the aid of such sensitive thermometers as are now manufactured had the process of enamelling not been introduced.

The enamel tube was *invented* by Negretti and Zambra.

2827b. Negretti and Zambra's Patent Mercurial Minimum Thermometer. *Negretti and Zambra.*

This thermometer has a plug of platina wire inserted in a small supplementary tube. When the thermometer is inclined, the mercury flows from the end of the supplementary tube until it reaches the platina plug, then by affinity of the mercury for the platina the column is maintained at the existing temperature; on a decrease of temperature the mercury recedes in the long or indicating tube, but on an increase of temperature it rises in the short tube, leaving the column of mercury in the thermometer indicating the minimum temperature.

2827c. Negretti and Zambra's Patent Recording Thermometer is upon the same principle as the deep-sea thermometer, but without the protected bulb.
Negretti and Zambra.

In this case the instrument is turned over by a simple clock movement, which can be set to any hour it may be desirable; the thermometer is fixed on the clock, and when the hand arrives at the hour determined upon, and to which the clock is set, as in setting an alarum clock, a spring is released, and the thermometer turns over (as in the case of the patent deep sea thermometer), transferring the mercury from the thermometer to the auxiliary or recording tube.

2827d. Board of Trade Thermometer. Original instrument, as used formerly in Her Majesty's service.

Negretti and Zambra.

The scale is brass, which, after constant use in salt water, soon becomes corroded and the figures obliterated.

2827e. Board of Trade Thermometers, with porcelain scales as patented by Negretti and Zambra, and now universally adopted. *Negretti and Zambra.*

2827f. Negretti and Zambra's Patent Self-registering Standard Maximum Thermometer.

Negretti and Zambra.

This instrument consists of a tube of mercury fitted on an engraved scale. The tube above the mercury is entirely free from air, and at a point in the bend above the ball is inserted and fixed with the blowpipe a small piece of glass, which acts as a valve, allowing mercury to pass on one side of it when heat is applied; but not allowing it to return when the thermometer cools. When mercury has been once made to pass the valve (which nothing but heat can effect) and has risen in the tube, the upper end of the column registers the maximum temperature.

2827g. Negretti and Zambra's Standard Minimum Registering Thermometer, on Rutherford's principle; an alcohol thermometer for recording the lowest temperature during any given period of time. *Negretti and Zambra.*

2827h. Negretti and Zambra's Patent Recording and Deep Sea Thermometer. *Negretti and Zambra.*

In shape this instrument is like a syphon with parallel legs. At the bottom on the left hand side there is a small glass plug or contraction on the plan of Negretti and Zambra's patent maximum thermometer. The mercury rises or falls as in an ordinary thermometer, but at the moment the temperature is desired to be recorded, the thermometer by a simple contrivance (which may be termed a vertical propeller) is made to pivot on its centre, causing the mercury to break off at the plug, and to pass into the right hand leg, where it remains fixed, indicating the exact temperature. The bulb is protected from the water pressure by an outer covering of thick glass, the intervening space being nearly filled with mercury.

2827i. Vacuum Solar Radiation Thermometer.

Negretti and Zambra.

The instrument consists of Negretti and Zambra's patent maximum thermometer with a blackened bulb enclosed in a glass tube and globe from which all air has been exhausted. This form of instrument was first made by Negretti and Zambra. An important addition (patented by Negretti and Zambra) to the instrument has since been made by inserting with the thermometer a small mercurial vacuum gauge, thereby showing whether a perfect vacuum has been obtained.

2827j. Negretti and Zambra's Thermometer for the determination of Terrestrial Radiation.

Negretti and Zambra.

The bulb of this instrument is transparent with divisions engraved on its stem. In use, to be placed with the bulb fully exposed to the sky, resting on grass with its stem supported by forks of wood. The divisions and figures are protected by an outer glass tube.

2826o. Original Self-registering Maximum Thermometer. Made by Prof. Phillips. *Hicks.*

Metallic Thermometer, Maximum and Minimum. By Hermann and Pfister, of Berne. *R. H. Scott, F.R.S.*

Wet and Dry Bulb Hygrometer. Same principle as that used with the thermometer No. 2827*e*. *Negretti and Zambra.*

Large Six's Self-registering Thermometer, with black scale on transparent glass. *Pastorelli.*

Small Six's Self-registering Thermometer, with two arms to tube. *Pastorelli.*

Delicate Thermometer, with gridiron bulb. The only instrument of the kind ever constructed. *Negretti and Zambra.*

Standard Meteorological Thermometer, with elongated bulb. *Casella.*

Standard Thermometer, with elongated bulb.

Elliott Bros.

Portable Wet and Dry Bulb Thermometers (hygrometer), with elongated bulbs, on brass stand. *Pastorelli.*

Small Portable Wet and Dry Bulb Thermometers (hygrometer), on black scale, with white figures and graduations, mounted on its own case. *Pastorelli.*

Wet and Dry Bulb Thermometers (hygrometer), with maximum and minimum thermometers, on one support.

S. G. Denton.

Wet and Dry Bulb Thermometers (hygrometer).

J. Hicks.

Wet and Dry Bulb Thermometers (hygrometer).

Negretti and Zambra.

Wet and Dry Bulb Thermometers (hygrometer), with elongated bulbs. *Casella.*

Six's Self-registering Maximum and Minimum Thermometer. *S. G. Denton.*

Six's Self-registering Thermometer, maximum and minimum. *Dring and Fage.*

Terrestrial Radiation Thermometer, on brass stand. *Pastorelli.*

Portable Maximum and Minimum Thermometers, mounted on their own case. *Pastorelli.*

Portable Maximum and Minimum Thermometers, on metal scales. *Pastorelli.*

2826o. Hicks's Patent Thermometer Shield. *J. J. Hicks.*

This is an arrangement for effectually protecting the figures and divisions of thermometers and other scales from the corrosive action of air and moisture, and consists of an outer glass tube hermetically sealed on to the thermometer stem whereby the scale is rendered absolutely indestructible. It his here exhibited, applied to maximum, minimum, and other thermometers.

2826p. Delicate Thermometers, with gridiron and spirally formed bulbs. *J. J. Hicks.*

By the diffusion of the mercury in the bulb over a large surface, and selecting tubes of small and uniform bore, very great sensibility is attained.

2826q. Six's Thermometer with Patent Cylinder Jacket Bulb. *J. J. Hicks.*

In this instrument by diffusing the spirit over an extended area, a degree of sensibility is attained equal to mercury.

2826y. Mercurial Standard Thermometer, by Troughton and Simms. *Royal Society.*

2826z. Spirit Thermometer, for very low temperatures, by Newman. *Royal Society.*

Hicks's Patent Terrestrial Radiation Thermometer. *J. J. Hicks.*

The difficulty arising from the condensation of moisture in the outer cylinder of ordinary terrestrial minimum thermometers, is, in this instrument, entirely obviated by simple but efficient means.

Highly sensitive Thermometers, with open scales in sets of six, one scale being continuous with the other, and so open as to admit of readings being taken to one-tenth of a degree. *J. J. Hicks.*

Hicks's Patent Solar Radiation Thermometer with electrical test. *J. J. Hicks.*

In constructing this improved radiation thermometer, special precautions are adopted to ensure perfection of vacuum, and the enclosing tube is furnished with platinum wire terminals to admit of the vacuum being tested by the electric current from a powerful Ruhmkorff coil by the aid of which the vacuum can be ascertained to exist to within one-tenth of an inch of pressure.

2827k. Thermometers of extreme sensitiveness.
Negretti & Zambra.

Negretti & Zambra's Instantaneous Thermometer, with gridiron, spiral, or coiled form of bulb, and divided upon the stem, as shown in the International Exhibition of 1862, and used by Mr. Glaisher in his balloon ascents to obtain very rapid thermometric readings.

2826g. Standard Thermometer, graduated on the stem, in maroon case, with Kew certificate. *L. Casella.*

2826h. Standard Maximum Thermometer, graduated on the stem (Kew certificate). *L. Casella.*

2826i. Sensitive Minimum Thermometer, with forked bulb (Kew certificate). *L. Casella.*

2826j. Thermometer, 2 meters long, set in wood and zinc, divided into $\frac{1}{5}°$, for investigations of terrestrial heat.
Warmbrunn, Quilitz, & Co., Berlin.

2826k. Two Thermometers, maximum, in case.
Will. Haak, Neuhaus, Thüringen.

2826l. Two Thermometers. Maximum on brass scale.
Will. Haak, Neuhaus, Thüringen.

2826m. Continuous Self-registering Thermometer.
W. Harrison Cripps, F.R.C.S.

The object of the instrument is to obtain a continuous registration of heat. The instrument is in two portions: 1st, the thermometer for indicating the temperature; 2ndly, the clock-work for registering the hours and minutes. The thermometer consists of six coils of glass tubing wound concentrically round an axis in such a manner as to form a spiral glass wheel 4 inches in diameter. The last coil is moved slightly away from the others, so that it shall form the circumference of a circle 5 inches in diameter. To each end of the axis a fine needle-pointed-pivot is attached. These pivots rest in minute depressions between two parallel metal uprights. By this arrangement the glass wheel can rotate freely between the uprights. The spirit in the thermometer fills the spiral portions of the tube, and also 3 or 4 inches of the last coil (the one forming the circle). The spirit then comes into contact with a column of mercury 4 inches in length. Beyond the mercury are a few drops of spirit to moisten the glass. The remaining portion of the tube is hermetically sealed, enclosing a small quantity of air. On the spirit expanding with heat, the column of mercury is driven forwards. This immediately alters the centre of gravity, and the wheel revolves in a direction contrary to that of the moving mercury. When the spirit contracts on cooling the enclosed air acting as an elastic spring keeps the mercury in contact with it, and the wheel regains its original position. By this arrangement the two forces, heat and gravity, acting in contrary directions, generate a steady rotatory motion.

The method by which this movement is made serviceable is by a grooved wheel 2 inches in diameter fixed to one of the pivots, and therefore revolving with the thermometer. Fixed to and passing over this wheel is a fine thread, from which is suspended a pencil holder, moving up and down on a vertical slide. The pencil will be raised or lowered according to the direction in which the wheel is moving. The other portions of the clock-work are arranged in a manner similar to that employed in the barograph.

In the present instrument a cylinder $4\frac{1}{2}$ inches, both in width and diameter, is made to revolve once in seven days. Around this cylinder is placed a paper, on which the days and hours are indicated by vertical lines. The cylinder is so placed that the surface of the paper is $\frac{1}{10}$th of an inch away from the pencil point, moving at right angles to its surface. A small striker is connected with the clock-work in such a manner that at every quarter of an hour it gives the pencil a tap, striking its point against the paper. The registration of the temperature is thus indicated be a dotted line which can be read off by a prepared scale supplied with the instrument.

The scale for reading off the register is prepared by observing the extent to which the pencil rises for every 10°, as indicated by a standard thermometer. In this particular instrument it is found that for every 10° the pencil is raised $\frac{3}{4}$ of an inch; this gives $\frac{3}{40}$ths for each degree, and the index is accordingly divided to this scale.

2826n. Fluctuation Thermometer. *Prof. Balfour Stewart.*

IV.—ANEMOMETERS.

2830. Static Anemometer, for measuring the force of the horizontal component of the wind, especially of gusts.
Scottish Meteorological Society.

Two sets of Robinson's cup anemometers are placed one above the other on one vertical spindle, so that the couple tending to turn the spindle depends on the force of the horizontal component of the wind, not on its direction. To the spindle is attached a spring, so that the magnitude of the couple (and therefore the force of the horizontal component) is measured by the angle through which the spindle is turned. This is recorded by a pencil which is raised and lowered by a screw cut on the spindle. The clockwork and paper for recording have not been sent. Designed by Professor Crum Brown, M.D., F.R.S.E., Member of Council.

2831. Anemometer, for ascertaining pressure of wind.
Scottish Meteorological Society.

This anemometer acts by lengthening (not compressing). The maximum result is recorded by the thread which is fixed to the rod and pulled through a hole in the brass plate fixed to the side of the box. To ascertain the maximum elongation which takes place, press the thread against the plate, then push in the disc until the part of the thread which has been drawn through the hole is again tightened, and read off the result from the graduated tube. The small disc is for high winds, the large for light. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Society's Journal, vol. iv., p. 266.

2832. R. Ballingall's Anemometer, for continually registering the pressure of the wind. *Scottish Meteorological Society.*

The principle of this anemometer consists in a cistern of mercury in the left hand chamber, with a wooden plunger, which acts in connexion with the pressure plate. There is an arrangement by which the accuracy may be tested at any time. Designed by the late R. Ballingall, and described at the general meeting of the Society, 2nd July 1874.

2834a. Anemometer, constructed by P. Schultze (Dorpat).
Prof. A. von Oettingen (Dorpat).

After 50 revolutions of the Robinson's cups an electrical contact is made, but only for a small fraction of a second, because after the movement of the differential wheel the electrical communication is broken, but at the same time prepared for the next operation.

2835. Anemometer (statical), in case.
Dr. G. Recknagels, Kaiserslautern (Physical Collection of the Royal School of Industry).

The indications of the instrument are proportional to the pressure of the wind. The small size of the instrument, and the ease with which its indications may be read off, make it specially advantageous for investigating ventilation. The velocities of the first revolution are marked on the outer scale; otherwise the constants are given with the apparatus. A small weight is added by way of a check; it balances the spring suspended at a mark of the hand.

2835a. Five Anemometers. *F. Darton and Co.*

2835b. Howlett's Anemometer. *Elliott Brothers.*

Consists of a copper sphere of such a diameter that the pressure of the wind on its hemisphere shall be equal to the whole or any required portion of a square foot; the sphere is mounted on a vertical rod that is suspended on knife edges like a balance, and registers the force and direction of the wind on a slate slab or on printed forms placed in the instrument for recording daily observations.

2836. Improved Anemometer of Combe.
Herm. Recke, Freiberg, Saxony.

All axle bearings in these anemometers are of stone. The setting and suspending is accomplished by pulling at one and the same knob. To facilitate the readings, dials with hands are provided. The fans are of trapezoidal shape and reach nearly down to the axle; they are of mica and capable of adjustment, in order to ascertain the most sensitive position.

2836a. Improved Anemometer of Combe.
Herm. Recke, Freiberg, Saxony.

In the preceding the axle of the fans remains unchanged during suspension inasmuch as only the dial work is moved; in this the axle is lifted parallel to itself.

2837. Pendulum Anemometer (drawing), with explanation. *Prof. Prestel, Emden.*

2838. Tangent Scale, for determining the mean direction of the wind. *Prof. Prestel, Emden.*

2839. Balance Anemometer, constructed by Mr. Francis Ronalds at the Kew Observatory, in 1843, for the purpose of measuring the force of the wind.
Kew Committee of the Royal Society.

It consists of a light board, 1 foot square, fixed transversely to a cross of wood, suspended by a brass axis passing through its centre, and turning in glass tubes in such a way that the system can partially rotate in a vertical plane. The lower end of the bar carrying the board is counterpoised, so as to keep the surface of the board vertical, and a scale pan, hung to one end of the horizontal bar of the cross, serves to receive the weights, which are necessary to counterbalance the force of the wind, pressing on the board opposed to it, at any time. A small box, covering the scale pan, serves to shield it from the action of the wind. The instrument was, at the time of observation, placed so that the surface of the pressure plate should stand at right angles with the direction of the wind, as indicated by a vane.

2841a. Anemometer, large. As supplied to the Government for registering on a diagram the velocity and direction of the wind. *L. Casella.*

2842. Electrical Anemometer, by which the velocity of the wind in miles, &c., can be shown on dials in an observatory or study. *Yeates & Sons.*

2843. Robinson's Anemometer, for measuring the wind's velocity reading from $\frac{1}{10}$ up to 1,000 miles. *Francis Pastorelli.*

This instrument consists of four hemispherical cups fixed to four strong metal arms, that radiate from a central boss at a distance of 90° apart; at right angles to the plane of the cups is attached the vertical axis, its lower end terminates with an endless screw; this works two wheels which differ in the number of teeth, so that by their common revolution one has 100 times less velocity than the other.

The front wheel has two divided circles, the interior denoting 10 miles; each mile is figured and sub-divided into 10 parts; the outer circle is divided into 100 parts; each of these divisions represent 10 miles, every fifth division 50 miles, and they are numbered 50, 100, &c.; therefore readings from $\frac{1}{10}$ up to 1,000 miles can be taken by this instrument.

2844. F. Pastorelli's Electric Anemometer, to indicate from $\frac{1}{10}$ up to 10,000 miles. By the use of this instrument the velocity of the wind at any distant station may be seen by inspection in the observatory. *Francis Pastorelli.*

It consists: (1.) of Dr. Robinson's cup arrangement attached to a vertical axis; as it revolves the motion is conveyed by its endless screw to a wheel with a cam mounted in a rectangular metal box; here the angular velocity is reduced, so that each contact has the value of $\frac{1}{10}$ of a mile; (2.) the receiving instrument with its dial is mounted in a polished cabinet; it is worked by an electro-magnet and lever, so when the revolutions of the cups have indicated $\frac{1}{10}$ of a mile, the action of the lever works a wheel, and motion is communicated to a series. On the face of the instrument are divided circles and indexes which register from $\frac{1}{10}$ to to 10,000 miles of velocity. (3.) A Leclanché battery of four No. 2 cells is connected with the above, so that each $\frac{1}{10}$ of a mile, indicated by the revolutions of the cups, may be transmitted electrically and consecutively to the receiving instrument.

This instrument has the minimum amount of friction. The cup arrangement can be placed in any distant and convenient position, and the receiving instrument in the observatory. It is portable, being of small dimensions.

2845. New Portable Anemometer, by Francis Pastorelli, for measuring accurately the velocity of the air or wind, specially adapted for scientific travellers and explorers. *Francis Pastorelli.*

It consists of four small hollow hemispherical cups (Dr. Robinson's form) fixed to a vertical axis; the lower end has an endless screw. This works a wheel, the complete revolution of which is equal to $\frac{1}{10}$ of a mile. Its action is conveyed to others that carry indexes over divided circles on the face of the dial, which is mounted on a circular box fixed on a metal base; readings can be taken from $\frac{1}{100}$ up to 1,000 miles. Its weight, $1\frac{1}{2}$ lbs., and it packs in a mahogany case about $4\frac{1}{4}$ inches square.

This is a most sensitive instrument; its indications are as accurate as those of the large kind.

2845a. Anemometer, with shaft whose length can be adjusted to suit different stations, and with dial reading to 10,000 miles, constructed for stations of the 2nd and 3rd order connected with the Canadian Meteorological service.

G. T. Kingston, M.A., Toronto, Canada.

This instrument is designed to reconcile adequate exposure of the hemispheres with accessibility of the dial.

A short spindle bearing a small set of Robinson's cups is connected with a horizontal cogged wheel resting on friction rollers, and with a long shaft suspended from its centre, as in the anemographs of the British observatories. It is contrived so that the shaft may make 101 complete turns for 200 miles of wind.

The mode of recording the miles is as follows:—

At the lower end of the shaft is an endless screw which acts on the circumferences of two toothed wheels of equal diameter, turning in vertical planes about a common axis, and having 100 and 101 teeth respectively.

From the centre of the *back* wheel (that of 100 teeth) projects forwards a short hollow pin which incloses and works on a solid pin fixed to a support behind the back wheel.

The *front* wheel (that of 101 teeth) which turns on the above named hollow pin, and slides closely on the face of the back wheel, has a graduated ring on its face, containing 100 divisions. The *outer* ends of the lines of graduation indicate miles, while the *inner* ends of the same lines, reckoned in the reverse order, indicate hundreds.

The endless screw, at every turn, causes both wheels to advance *two* teeth, so that for 100 miles the front wheel makes one complete turn, or 100 divisions, while the back wheel make one complete turn and one tooth, and thus advances one division with respect to the front wheel. The miles up to 100 are shown by a fixed pointer, and the hundreds by a pointer attached to the end of the hollow pin.

For fractions of a mile there is a contrivance which needs adjustment at each observation.

A correction of 1 per cent. nearly should be subtracted from the fractional parts.

If the anemometer be two distant from the observer's office to allow the dial to be read conveniently with the required frequency (if, for instance, it be on an adjacent hill or tower), it may be connected electrically with a dial or with a self-recording apparatus.

In such a case, the dial above described should be read periodically as a check on the electrical dial.

To adopt the length of the shaft to the circumstances of various stations, the shafting is supplied in lengths of four feet, with one of two feet, one of one foot, and one telescopic piece.

2845b. Windmill Vane with electrical arrangement whereby the direction of the wind at any instant may be known by sound, constructed for stations of the second and third order in connection with the Meteorological Office of the Dominion of Canada. *G.T. Kingston, M.A., Toronto, Canada.*

This instrument is designed to meet the case when a vane, if suitably exposed, is too distant to admit of being connected by a shaft with a dial in an accessible position.

Surrounding the step of the vane and attached to the bottom of the box is a flat brass ring divided by radial lines into four equal parts corresponding to, but not necessarily in the direction of the four cardinal points, and separated by small equal intervals.

The direction arcs (as they may be termed) are insulated, except as regards connection with their screw cups.

Clamped to the spindle, and capable of adjustment in azimuth, is a circuit maker, which consists of an arm bearing a brass arc, which is made to press on the flat brass ring. The length of this arc is 45° + interval between the fixed arcs. The step of the vane is connected by wire with one pole of a battery, and the direction arcs with four screw cups in near proximity to a brass plate fastened to the wall of the office, and so contrived that, by aid of a plug, metallic connection may be made at will between the brass plate and any one of the four wires.

Finally, two wires from the poles of a small telegraph sounder are attached to the brass plate and to the other pole of the battery, and the apparatus is complete.

To ascertain the direction of the wind, notice by the sounder which direction arcs or pair of arcs is placed in circuit as the brass plate is connected by the plug with the four wires in succession.

If, for instance, N. only sounds, the direction is nearer to N. than either to N.W. or N.E., unless it be N.N.W. or N.N.E. exactly, but if N. and E. *both* sound the direction is nearer to N.E. than either to N. or E., unless it be N.N.E. or E.N.E. exactly.

The azimuth of the vane box need be governed only by appearance and the position of the door.

To adjust the vane, unclamp the circuit maker, and insert a pin (provided for the purpose) through holes at the middle point of the circuit maker and the arc at the left of the box, which arc may represent any one of the four cardinal points. Turn the vane to that point, clamp the circuit maker, and remove the pin, when the adjustment will be complete.

The apparatus works well with a single gravity cell, when the vane is 60 feet or more from the battery and sounder. With a stronger battery it works well at the distance of a mile or more.

3388a. Signor Bianchi's Air Meter.
Conservatoire des Arts et Métiers, Paris.

V.—RAIN GAUGES.

2847. Rain Gauge. In use at meteorological stations belonging to the Norway Meteorological Institute.

Prof. H. Mohn, Christiania.

Square surface, 15 × 15 centimetres, height 50 centimetres, for catching snow; the lower part protected against evaporation. The rain (or melted snow) water is to be poured out of the gauge through one of its upper corners, into a measuring cylindrical glass, divided to show the height of fallen rain in millimetres. The gauge is made of plate iron, after design made by Professor H. Mohn. The measuring glass was calibrated at the Meteorological Institute, in Christiania.

2848. Rain Gauge, No. I. *Scottish Meteorological Society.*

Designed to obviate errors due to out-splashing and in-splashing of rain drops. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Edinburgh Philosophical Journal, 1842.

2849. Jagga's Rain Gauge, No. II.

Scottish Meteorological Society.

The principle of this gauge consists in making the diameter of the funnel equal to 4·697 inches, so that a fluid ounce of the rain-water collected equals one-tenth of an inch of rain. Designed by G. V. Jagga, Rao of Vizagapatam, and introduced to the Society by Sir Walter Elliot, Member of Council, and described in the Society's Report, quarter ending June 1861, p. 9.

2850. Marine Rain Gauge.

Scottish Meteorological Society.

This instrument is composed of a cylinder poised on an upright pivot projecting from the bottom of a square box, enclosing the whole, having the top open to the atmosphere. The cylinder is divided into two parts, an upper one having a diaphragm to collect the rain, and the lower, the receiver for the same having a conical floor inside in which works the pivot below. The horizontal bearing of the gauge is thus maintained in all cases of the rolling and pitching of the vessel by the motion on the pivot.

2851. Ronalds' Rain and **Vapour Gauge,** erected at the Kew Observatory in 1843.

Kew Committee of the Royal Society.

An instrument constructed at the Kew Observatory in 1843, by Mr. Francis Ronalds, for indicating a mean result from the quantity of water which may have fallen between any two given periods, *minus* the quantity of vapour which has evaporated in the same time, on and from a circular plane of one foot diameter. It is described in the British Association Report for 1844.

It consists of two cylindrical vessels, connected by a tube, the one being one foot in diameter, and open at the top, whilst the other is 3 inches, and (with the exception of a small hole) entirely closed by a cover, which carries a frame, holding a circular divided arc, with an index moving over it. The index is attached to a small pulley, over which a cord passes, having its end fixed to the float in the cylinder. This, rising and falling with the changes of water level, indicates the amount of rain or evaporation on the metal scale.

2851a. Stutter's Self-recording Rain Gauge.
J. J. Hicks.

This is a step in the direction of cheapness without sacrificing efficiency. An eight-day clock rotates a funnel, the tubular end of which passes successively over the openings of 12 or 24 glass jars numbered to correspond with the hours of the day. The funnel-shaped openings over each jar being brought to a knife edge, a well defined separation is effected, so that each jar receives the rain for each hour, and the sum of their contents gives the rainfall for 12 or 24 hours.

2851b. Beckley's Self-recording Rain Gauge, as used at the observatories in connection with the Meteorological Office.
The Meteorological Committee of the Royal Society.

This instrument is described in the report of the Meteorological Committee for 1869.

The rain is delivered into a receiver floating in mercury. As soon as 0·2 in. of rain has been collected a syphon arrangement is brought into play, and the receiver is emptied and rises to its original position.

The motion of the receiver is recorded on paper by a pencil.

2852. Glaisher's Rain Gauge. *Francis Pastorelli.*

This instrument has a greater internal depth, the coned part being 3 inches from the surface; in this respect it more resembles the Admiralty pattern; it prevents heavy rain splashing over, and consequent loss.

2852a. Mountain Rain Gauge. Capacity 48 inches. Pattern employed in the English lake district and at very wet mountain stations in Wales and Scotland. *G. J. Symons.*

2852b. Engineer's Rain Gauge. Capacity 12 inches. Adapted for rough observations in ordinary hilly districts.
G. J. Symons.

2852c. Glaisher's 8-inch Rain Gauge. Adapted for, and largely used by, private observers. *G. J. Symons.*

2852d. Snowdon Pattern Rain Gauge, originally designed for use in North Wales, the deep cylinder being added to secure accurate observations during snow. This gauge is now in general use in all parts of the British Isles. *G. J. Symons.*

2852e. Indestructible Monthly Rain Gauge for private observers. *G. J. Symons.*

3852f. Copper Rain Gauge, Glaisher's form.
E. Cetti and Co.

2852g. Electrical Self-registering Rain Gauge.
Yeates & Sons.

The peculiarity of the above is a novel form of rocking bucket, the partition of which is so constructed that it will register correctly, no matter at what rate the rain may fall.

2852h. Self-registering Rain Gauge. *Elliott Brothers.*

This instrument consists of an upright square metal case, with funnel or receiver 10 inches square, with a set of counting wheels with dials registering from $\frac{1}{100}$ to 100 inches of rain fallen. The water falls into a trough with a division in the centre, having a motion on an axis, and being put at an angle, the rain overbalances it alternately, and is registered by the motion being communicated to the set of wheels, and consequently there is no evaporation to be deducted.

Funnel, Bottle, Copper Pan, and Glass Measure for Rain Gauge. *F. Darton and Co.*

VI.—HYGROMETERS.

Mostra Umidaria (Hygrometer). An invention of Folli da Poppi, perfected by the Accademia del Cimento; the hygroscopical body is a band of paper. *The Accademia del Cimento.*

Hygrometer, at condensation, invented by the Grand Duke Ferdinand II. dei Medici. *The Accademia del Cimento.*

Folli's hygrometer, made in 1664, consists of a band of paper fixed at both ends, and having in the middle a corresponding weight, which in its rising or falling (caused by the moisture shortening or lengthening the paper) transmits its motion by means of a cord and pulley, to a hand which points out the degrees of humidity on a quadrant. The members of the Accademia del Cimento substituted parchment for paper, whilst Torricelli used oats as an hygrometric substance.

The hygrometer No. 23, that of the Grand Duke, is founded on the principle of the condensation of the aqueous vapour of the atmosphere, by means of a cold substance. It consists of a truncated cone, made of a sheet of tinned iron, covered on the inside with a layer of cork, and supported on a tripod. Below the smaller aperture, turned downwards, there is suspended a hollow glass cone, ending in a closed point likewise turned downwards, and provided towards the upper part with an escape pipe. The upper cone is then filled with snow or ice, which in melting runs into the glass cone, which remains at the temperature of 0°, whilst the excess of water runs through the pipe into a separate vessel. The moisture of the air coming in contact with the cold side, condenses itself and covers it with dew, which collecting by degrees into drops, runs towards the point whence it falls into a graduated vessel. If the time the experiment has lasted be taken into consideration, the quantity of water thus collected will be found to be in proportion to the humidity of the air.

Experimenting in this manner, the members of the Accademia del Cimento, found that the south winds are so charged with moisture, that in one minute the hygrometer has given as much as 35, 50, and even 80 drops of water; whilst the north wind leaves the glass perfectly dry.

2853a. Capt. Kater's Hygrometer, by Robinson. *Royal Society.*

2853b. Jones' Hygrometer, with stem bent at an acute angle. *Royal Society.*

2863a. Chameleon Hygrometer, based on the property of cobalt of changing colour with the dampness or dryness of the air. *Walter B. Woodbury.*

2871g. Slide Rule for hygrometrical calculations by John Welsh, F.R.S. *Surgeon-Major F. de Chaumont.*

2971h. Mason's Hygrometer. *E. Cetti & Co.*

2853. Saussure's Hygrometer; an old specimen by V. F. Hausman. *G. J. Symons.*

2854. Whalebone Hygrometer, by Thos. Jones, of Oxendon Street. *G. J. Symons.*

2855. Daniell's Hygrometer. No maker's name, but formerly belonging to Sir James South. *G. J. Symons.*

2856. Balance Hygrometer (drawing and essential part of the instrument). *Prof. Buys-Ballot, Utrecht.*

At one arm of a balance is hung a wide glass tube filled with chloride of calcium or any other hygroscopic substance. This tube is closed at its upper part by a cork stop, bearing two bent glass tubes plunging in oil baths, but care is taken not to submerge their open ends. Two glass bells, ending in tubes at their upper parts and plunging for nearly half an inch in the same oil, render it possible to aspirate air through the chloride of calcium tube without affecting its movability. One of the bells is joined by an india-rubber tube with the spot the air of which is to be examined; the other with a gas meter and aspirator. In a given time the water contained in a quantity of air indicated by the gas meter can in this manner be weighed, and its humidity ascertained. It is obvious that the instrument can easily be made self-registering.

2857. Collection of **Hygrometers** and **Psychrometers.** *Dr. H. Geissler, Bonn.*

2857a. Standard Hygrometer, with divisions and figures, protected by an outer glass tube, as in Negretti and Zambra's terrestrial radiation thermometer. *Negretti and Zambra.*

2857b. Negretti and Zambra's Standard Dry and Wet Bulb Hygrometer or Psychrometer. *Negretti and Zambra.*

Two thermometers as nearly identical as possible are placed side by side, one marked DRY and the other WET. The bulb of the wet thermometer is covered with thin muslin, and has twisted round the neck conducting threads of cotton, passing into a vessel containing water placed on one side so that the water may not affect the reading of the dry bulb thermometer. The temperature of the air and of evaporations is given by the reading of the two thermometers, from which can be calculated the dew point.

2858. Klinkerfues' Bifilar Hygrometer, with reduction disc, executed by W. Lambrecht, Göttingen.

Prof. Klinkerfues, Göttingen.

The bifilar hygrometer shows the relative dampness without further reduction, upon a stereotyped scale of equal divisions, and also the dew point by means of the reduction disc.

2859. Reduction Discs for Psychrometers.

Prof. Klinkerfues, Göttingen.

The reduction discs for the psychrometer give the dew point according to the following rule:—

The outer disc is turned round the inner one in such a manner that the two places of the evaporation temperatures, read off from the moist thermometer, coincide; with the place of the air temperatures upon the one will then also coincide the place of the dew point temperature upon the other. The one disc has a second division, which comes into use in the case of the evaporation temperature falling below zero.

The barometric pressure is assumed to be 750 mm.; for any other pressure, b, the quantity $\frac{4}{30}$ $(b-750)$, taken in nearest round numbers, can be easily multiplied in the head by the thermometric difference, likewise taken in round numbers. The product expresses the number of hundredths of a degree, and has to be added to the air temperature, in order to obtain, after the setting of the disc, the dew point with greater precision. This correction is, however, seldom required in practice.

2861. Psychrometer Scale, for determining the relative and absolute moisture of the air, as well as the dew-point, without calculation. Model with explanation. *Prof. Prestel, Emden.*

2862. August's Psychrometer, with two thermometers divided into ·1° on a stand. *Warmbrunn, Quilitz, & Co., Berlin.*

2863. Catgut Hygrometer, dating from the first quarter of the 18th century. Property of His Highness the Prince of Pless.

Breslau Sub-Committee (Prof. Poleck).

Interesting on account of its age.

2864. Eight-Haired Saussure's Hygrometer, by Richer of Paris, formerly the property of Mr. Francis Ronalds, and used by him at the Kew Observatory in 1843.

Kew Committee of the Royal Society.

2865. Three Hair Hygrometers, by H. B. de Saussure.

M. Henri de Saussure, Geneva.

Original models, originally the property of M. H. B. de Saussure, accompanied by tables drawn up by him and his son Theodore de Saussure.

2867. Hair Hygrometer of De Saussure, with two sets of graduations, one being fractional of relative moisture.

Geneva Association for the Construction of Scientific Instruments.

The faults found with the hair hygrometer are caused, generally, by the very great imperfection of the manufacture of those usually sold by the trade. The hair deteriorates, and from time to time its indications alter, because, as a rule, the weight of tension is too great. Hair properly prepared, and subject to due tension only, altered so little that M. Regnault tells of having found an old hygrometer made by Paul as correct as any modern instrument with which he has compared it. Another cause of irregularity proceeds from the careless choice of the hair. All hair that has been pulled about, and of which the limit of elasticity has been exceeded, should be avoided. The most isolated hamlets have now to be searched in order to obtain hair uncombed. The object of the Geneva Association for the Construction of Scientific Instruments is to revive the hygrometer of De Saussure in an improved form. The general construction of the De Saussure hygrometer has been maintained as being the best, but the following modifications have been introduced:—

1st. The marking needles on the axis of the pulley are made of aluminium bronze, thus making the pulley lighter, consequently more moveable, and lessening the friction of the axle.

2nd. The weight of tension of the hair is replaced by a gold spiral, which makes the instrument more portable and avoids the twitching of the hair by oscillation and accidental displacement of the weight.

3rd. The hygrometer has two graduations (this is the chief modification); the first is an arbitrary division in equal parts of 0 to 100; the second marked out on a moveable arc, is superposed to the first and registers in hundredths the relative moisture, or the fraction of saturation. Thus, when the hygrometer registers 50, it is certain that the air contains half the quantity of water that it can contain in the state of saturation.

The hygrometer is graduated according to "Regnault's" method.

2868. Hygrometer, modified by Dr. Geissler, with a delicate thermometer on a stand.

Will. Haak, Neuhaus am Rennweg, Thüringen.

2869. August's Psychrometer, on stand. The thermometer divided into tenths of a degree from −30 to +45° C.

Will. Haak, Neuhaus am Rennweg, Thüringen.

2870. Psychrometer, August system, with stand, in a case.

Ch. F. Geissler & Son, Berlin.

2870a. Psychrometer, August system, with stand, in a case, for travelling. *Ch. F. Geissler & Son, Berlin.*

2871. Early Hygrometer.

The Council of King's College, London.

2871a. Oatbeard Hygrometer. *G. J. Symons.*

2871b. Old Travelling Hygrometer. *G. J. Symons.*

2871c. Modern Saussure's Hygrometer. *G. J. Symons.*

2871d. Mason's Wet and Dry Bulb Hygrometer for Observatories. *L. Casella.*

2871e. Pocket Hygrometer, in maroon case, for travellers. *L. Casella.*

2871f. Dine's Sensitive Hygrometer, for taking rapid indications of the dew point. *L. Casella.*

VII.—SELF-RECORDING INSTRUMENTS.

Barometrograph of Fontana. *The Royal Institute of "Studii Superiori," Florence.*

Felice Fontana, a native of Roveredo in the Tyrol, was the first director of the Royal Museum of Physical Science and Natural History founded in Florence by the Grand Duke Pietro Leopoldo. Towards the close of last century he constructed several registering meteorological instruments, and among them the present Barometrograph. A float on the surface of the mercury of a large barometer transmits its motion to a section of a cylinder about 70 mm. in diameter, and covered with paper. Every hour an impression is made upon this paper by a steel point set in motion by a clock. The point itself advances a certain distance at each impression, so that its indications end by drawing on the paper, a curve of the barometical oscillations.

2872. Barometrograph, or Self-Recording Aneroid Barometer. *Pillischer.*

The construction of this instrument differs materially from others of a similar nature, by having the entire mechanism placed in a vertical line, whereby friction is reduced to a minimum.

The aneroid barometer, 18 inches in diameter, has two vacuum chambers; below it is placed the cylinder, carrying a ruled paper coinciding with the scale of the barometer, and driven by a powerful 8-day clock. The pencil point is moved up and down upon a metal rod by the action of the barometer, and, by a simple mechanical arrangement connected with the clock, imprints the changes which occur from hour to hour on the ruled paper. Thus a black dotted undulated line is produced, showing the rise and fall of the barometer.

2873. Self-recording Barometer and Thermometer for use on board ships.

Dr. Franz Paugger, Director of the I. R. Commercial and Nautical Academy, Trieste.

This apparatus, which is enclosed in a small box, consists of three principal parts:

A thermometer, a barometer, and a contrivance for registering.

The thermometer is composed of a system of 10 zinc tubes, one foot (English) in length, placed side by side in the form of a cylinder, each one of which, commencing from the first, transmits, by means of a lever, to the next tube, in a somewhat augmented degree, its linear expansion produced by increase of heat. This system of tubes is suspended in the open air and surrounded by a shell or cover in the form of venetian blinds at the back or the parallel tubular box. From the end of the last tube a somewhat longer lever extends into the interior of the box, as far as the writing cylinder, by which the variation of the temperature, caused by the total expansion or contraction of the tubular system, is automatically recorded from time to time. The motor for the measurement of the atmospheric pressure is composed of 10 aneroid cases, which are joined together in the shape of a column. Their expansion or contraction, produced by the changes in the atmospheric pressure, is transmitted to the writing cylinder by means of a lever.

The arrangement for registering consists of a cylinder placed vertically, which is turned on its axis every 24 hours by a clock movement in the front part of the box. The two levers, both extending horizontally from the thermometer and the barometer, as far as the same edge of the cylinder, are at a mean temperature and a mean atmospheric pressure in a position the one in the centre of the lower, and the other in the centre of the upper half of the writing cylinder. Every 15 minutes, the ends of the levers, which are provided with pencils, are pressed against the cylinder, and by these means the variations of the atmospheric pressure and of the temperature are regularly registered. The instrument is in all its parts so contrived as not to require a fixed position, and being easily transportable, it can be used without difficulty on board ship.

2873a. Self-registering and Signalling Vessel Barometer.

Dr. Friedr. C. G. Müller, Osnabrück.

This self-registering and signalling barometer is new, both as a whole, and in its details. The points of novelty are:

I. The bulb barometer, which is entirely independent of the registering and signalling mechanism, and which possesses the following properties:—(*a.*) The reading takes place at the *lower* level by unchanged position of the upper. (*b.*) The galvanoscopic adjustments, accomplished by means of the platinum point fused into the Torricellian vacuum, requires no sight, is very simple, quickly performed, and free from errors. (*c.*) The construction of the cistern with the barometric tube passing through it, whereby the level of mercury in the cistern is kept invariable. (*d.*) No boiling of the tube is required. (*e.*) By the introduction of a small quantity of dry hydrogen into the vacuum, the influences of temperature may easily be compensated.

II. The uninterrupted automatic adjustment, which makes all changes in the atmospheric pressure, even the smallest oscillations, *audible.* Specially deserving of attention are:—(*a.*) The two platinum points in connexion with (*b.*) the two sliding relays, working in opposite directions, and (*c.*) the two little electro-motor machines, which by their beats give direct indication of all variations in the atmospheric pressure, and announce it indirectly by setting an electric clock-work into action. (*d.*) By connecting the two relays with the same point, the utmost sensitiveness of the automatic adjustment is reached, whilst the machines are in continuous action.

III. The registering mechanism, which is connected with the self-regulating barometer cistern, and moving in which the mercury in the barometer has no work to perform. Attention is called to the following points:—(*a.*) The force moving the marking pencil is a considerable one, in consequence of the multiplying gear; the wheels have to revolve 80 times in order that the cistern may move 1 mm. (*b.*) The registering mechanism allows, without losing anything of its simplicity and reliability, a magnifying of the movement of the barometer cistern. (The present apparatus doubles the movement.) (*c.*) The instrument continues working for a month, and even longer, without interruption. (*d.*) The introduction of a new slip is easily accomplished in about one minute, and no new correction is then required. (*e.*) The second fixed pencil marks along the margin of the paper slip a line, which by being broken every three hours marks the time. This line determines also for the subsequent measuring of the curve the adjusting of a transparent scale, with the co-ordinate lines of time and height.

IV. Finally, the mechanical execution of the apparatus, which comes from the establishment of Herr *Wanke*, is deserving of attention.

2873b. Photographic Thermograph, as employed at the seven observatories of the Meteorological Committee. Described, Report of Meteorological Committee of Royal Society for 1867.
The Meteorological Committee of the Royal Society.

2874. Electric Registering Anemometer with momentary contact contrivance.
Prof. Osnaghi, Imperial Central Meteorological Institute, Vienna.

The apparatus registers each kilometre by marks impressed on a slip of paper moved by clockwork.

2875. Wind-Current Autograph, or Registering Apparatus. *John G. Schoen.*

This "Wind-Current Autograph" marks, or registers, continuously and correctly, on a strip of paper moved by clockwork, the motion or direction of the currents of wind in such a manner that the time is indicated as the abscissa, and the angle of elongation of the weather-vane towards the north shown at every particular moment, as the ordinate.

2876. Electrical self-recording Anemometer and Printing Apparatus, invented by the Exhibitor.
J. E. H. Gordon.

The figures on the left hand side of the paper give the hours, those on the right the direction of the wind at each quarter of an hour, while for every mile of wind that passes over the cups on the roof a dot is made in the centre of the paper. The number of dots between any two consecutive figures is the velocity in miles per hour for that hour. The communication with the roof being made by electricity no shaft is required.

2877. Automatic Light Registering Apparatus.

A. Salted paper.
B. Silver nitrate solution.
C. Trough for silvering paper.
D. Drying reel.
E. Dark box.
F. Insolator.
G. Cover for insolator.
H. Clock.
K. Battery.
L. Punch.

M. Reading-off apparatus :—

a. Drum.
b. Graduated strip.
c. Stand.
d. Sodium carbonate.
e. *e*. Platinum wires.
f.*f*. Stands for platinum wires.
g. Bunsen burner.
h. Lens.
k. Spirit lamp.

Prof. H. E. Roscoe, F.R.S.

This method depends on the fact that the depth of colour produced on a properly prepared chloride of silver paper is directly proportional to the intensity of the light multiplied by the time of exposure.

The apparatus consists therefore essentially of two parts, one in which the prepared paper can be exposed for definite periods of time to the action of the light, and a second part in which the intensity of the tint obtained can be determined.

The paper (A), previously salted by immersion for five minutes in a 3 per cent. solution of sodium chloride, and cut into strips, is silvered by floating for two minutes in a 12 per cent. solution of silver nitrate (B), contained in the long trough (C), and afterwards dried on the reel (D).

The prepared paper may be preserved either before or after exposure in the dark box (E). It is next wound on to the bobbin of the insulator (F), which is placed in electric communication with the clock (H) by means of the battery (K); the free end of the paper, passing over the large wheel, being held in position by means of a small pin on the inside circumference of the wheel.

When a current of electricity passes, the magnet attracts the armature, and the wheel moves through a small space; the circuit is immediately broken and the armature released, and this slight movement of the wheel is repeated every time a current of electricity passes through the apparatus. The insulator is provided with a cover (G), in the top of which is a small circular hole, against which the prepared paper is pressed by means of a spring, and as the wheel revolves, fresh portions of the paper are successively brought under this hole, and thus exposed to the action of the light. The mechanism of the clock is so arranged that discs of prepared paper shall be exposed to the action of the light each hour for 10 different periods of time, which have been exactly determined, varying from 2 to 30 seconds, the object of this being to obtain, either with the feeble light of the morning, or the strong light of mid-day, a tint neither too light nor too dark to be read off. This is accomplished by means of a large metal disc in the clock, which revolves once in two minutes, and is in metallic connexion with one pole of the battery. On the face of the disc are placed 11 platinum pegs, arranged at equal distances from the centre of the disc, but at such different distances from one another that the first 10 intervals correspond as closely as possible to 2, 3, 4, 5, 7, 10, 12, 17, 20, 30 seconds respectively (their values being afterwards experimentally determined to one-fifth of a second), whilst the value of the last interval is of no importance. The other pole of the battery is connected with a metallic lever tipped with platinum, the insulator forming a part of the circuit.

Each hour this lever is lowered mechanically so that it comes in contact with the first platinum peg; the circuit is completed, the magnet in the insulator attracts the armature, causing the wheel to make a small fraction of a revolution, and a fresh surface of paper is exposed to the light. Contact is immediately broken, the peg passing away from under the lever, to be again made when the next peg passes by, and so on through one revolution of the disc. After the 11th peg has passed by, the lever is automatically raised, and remains out of contact till the next hour. The last exposure, therefore, corresponds to the interval, the value of which has not been determined, this portion of the paper remaining exposed until the next hour.

After the apparatus has been in work for 24 hours the strip of paper is exhausted, and must be replaced by a new one.

On the paper thus exposed will be found repetitions of a series of 10 discs, of a tint which in each series gradually increases in intensity, separated by one black disc when the paper has been exposed for the whole hour. One half of two or three of the discs in each series is cut away by the semicircular punch (L), and the intensity of the tint in each case read off. For this purpose the apparatus under the glass case (M) is employed. Round the drum (*a*) is pasted the graduated strip (*b*), the intensity of the tint on any point on which may be found with reference to a table prepared for the purpose. The drum revolves freely on the stand (*c*). The paper to be examined is placed over the graduated strip, being held in position by the two clamps attached to the stand.

By means of the semi-circular hole, which has been punched into the exposed paper, the tint of the paper and of the graduated strip are brought side by side, and by revolving the drum with the hand various portions of the graduated strip are brought successively into juxtaposition with the tint of the exposed paper, and when the two tints are seen to be identical, the value of the exposed tint is known, corresponding of course to the one for that point on the graduated strip, and ascertained by reference to the table of intensities. A number of such readings for each tint are obtained and the mean taken as correct. These comparisons must be made by the light of the monochromatic soda flame.

Beads of sodium carbonate (*d*) on the platinum wires (*e*, *e*,) are held by means of the stands (*f*, *f*,) in the flame of the Bunsen burner (*g*), and the rays of light are concentrated on to the strip by the lens (*h*). When gas is not available the spirit lamp (*k*) is employed.

It now remains alone to divide the value of the tint thus obtained by the number of seconds which the tint has been exposed, to determine the intensity of the light for one second of time, which is the standard adopted. Two or three of the discs obtained each hour are thus read off, and the mean taken as representing the correct intensity.

2877a. Insulator and Whirling Apparatus.

Capt. Abney, R.E., F.R.S.

This instrument is based on the same principles as that of Professor Roscoe, but it was constructed with the idea that its portability may cause it to be employed in localities where his larger apparatus might be too bulky.

It consists of a revolving cylinder (round which is wound sensitive paper), driven by clockwork enclosed in a cover. In the cover is a narrow slit, extending across the cylinder, over which is pressed a black glass wedge of known graduation. The light falls through the wedge on to the paper in different gradations, according to the intensity of the light. The integration of the darking is obtained by placing the cylinder in a whirling machine, and the position of the standard tint is noted on a scale which depends on the graduation of the wedge. The total insolation is thus arrived at. When Professor Roscoe's and this instrument are worked together the results are accordant.

2879a. Full sized Lever Anemometer for registering the pressure of the wind.

C. O. F. Cator, M.A.

The pressure-plate is circular, has an area equal to 1 square foot, and is kept constantly face to wind by a vane (or by windmill fans); as it is driven forward by the wind, its motion is conveyed by means of a wire to a pencil, which continuously records every movement on paper revolving by clockwork below.

The peculiarity of this instrument is, that, instead of employing springs as the resisting medium, which from their proximity to the pressure plate and consequent continual exposure to the weather, cannot always preserve the same strength and elasticity, the resistance is furnished by a system of leverage. This consists of two eccentric curves of different sizes rigidly connected together and revolving on the same axle, of which the curvatures decrease respectively in opposite directions, so that the effect is doubled. Round the larger one a cord is carried, from which hangs a fixed weight. Round the smaller one a chain is passed, which is connected directly with the pressure plate, and also with the recording pencil. As the motion is direct, the spaces moved through by the pencil and by the pressure plate are exactly equal to another one and also to the primeter of the smaller curve.

One great advantage of this apparatus consists in its close proximity to the recording pencil, and in fact that the resistance is always the same, as every part of the instrument except the pressure plate is under cover and free from exposure to the weather. Another peculiarity of this instrument is that the plate is furnished with a conical back, so as to diminish the error arising from the formation of a partial vacuum behind it in strong winds.

The direction of the wind is also continuously recorded by Beckley's method, on the same paper as the pressure.

2880. Whewell's Anemometer. *Elliott Brothers.*

Consists of a delicate wheel with vanes and endless screw, working a series of cog wheels, which communicate with an ordinary lead pencil, that registers the force and direction of the wind on a vertical japanned cylinder. The cylinder is enclosed in a wooden case to prevent it from being injured by exposure to the weather.

2882. Registering Aneroid Barometer, for showing at a glance the various fluctuations that have taken place in the barometer. *Elliott Brothers.*

2883. Howlett's Portable Anemograph, an instrument which records the varying direction and force of the wind in the form of a map. *Elliott Brothers.*

2885. Self-recording Aneroid for Hall or Library; a graphic delineation of the change in pressure of the air for each week can be seen at a glance. *Francis Pastorelli.*

Fixed nearly in line, in a case, is an aneroid, an eight-day clock, and a revolving cylinder that occupies the central position; it is covered with metallic paper ruled for the days of one week, with the barometric scale in inches and tenths; upon this is marked every hour the pressure of the atmosphere; the markings have the appearance of a curved line, and the rise and fall of the barometer is seen at a glance for every hour of each day for one week, when a new paper has to be placed on the cylinder. The index hand on the dial of the aneroid indicates the pressure of the air at the time of observation. Having already described the construction of the aneroid, it is only necessary to explain the method by which it is made self-registering. Connected with the lever that carries the chain round the arbor is a long watch chain that passes through the top of the aneroid over a pulley; it terminates with a metallic point, which is kept in working position by means of a vertical bar; this is capable of revolving upon its points. Behind the metallic point or pencil is the vertical revolving cylinder covered with the metallic paper; this is moved by the clock, which also presses the pencil point down upon the paper, and leaves a mark at each hour.

2887. A. Von Oettingen's "Self-recording Wind Components Integrator." Constructed by P. Schultze.

Dr. Arthur Von Oettingen, Professor at the Imperial University, Dorpat (Russia).

The wind moves a system of hemispherical cups, like Robinson's, (which motion is replaced by clockwork for exhibition) acting on a circular plate, whose velocity is ordinarily proportional to the velocity of the wind. Four systems of sliding-rollers rest on this plate, whose bearings can be moved round a vertical axis, the principal planes of which imitate all variations of a wind vane. Each sliding roller can rotate about a horizontal axis, but only in one direction, and after a half rotation an electrical contact is made. A mechanism limits the contact to a fraction of a second. When the contact is made, one of four wheels, with number-types, is moved. Every half an hour the position of these four wheels is shown by printing numbers on a strip of paper. The differences of those readings represent the mean volocity of the wind from N., E., S., and W. They are converted into absolute values by means of a table. Different mechanism adjusts the portion of every sliding roller.

2888. Complete Meteorograph.

F. Van Rysselberghe, Ostend.

4553. Drawings, on a large scale, **of the Meteorograph** of Padre Secchi, with printed description annexed.

Observatory of the Collegio Romano, Rome; Director, Padre Secchi.

AUTOMATIC REGISTERING APPARATUS.

2889. Photographic Proofs, obtained at various depths and at different seasons, to ascertain the penetration of the solar rays in the waters of the Lake of Geneva.

Prof. Dr. F. A. Forel, Morges, Switzerland.

From these observations it has been found that the extreme limit of penetration at which the solar rays are capable of acting on chloride of silver is—

1. In the summer, when the water is, relatively speaking, not very clear, from 40 to 50 metres deep.
2. In winter, when the water is less clear, 90 to 100 in depth.

To enable a comparison to be made with the clearness of the water in other lakes and in the ocean, and to give an idea of the degree of transparency of the waters of Lake Leman, it should be mentioned that on the 10th March 1875, at noon, the sun being at 39° 10′, a white plate or plaque 25 centimetres in diameter became invisible at a depth of 17·0 metres.

2890. Drawings of the principal parts of a meteorological registering apparatus, viz.:—

a. Scale-barometer, natural size.
b. Instrumental thermometer, natural size.
c. Air thermometer, natural size.
d. Clock-work and registering contrivances for only one of these instruments, since the mechanisms of all of them are identical; natural size. *Dr. P. Schreiber, Chemnitz.*

The apparatus represented in the drawings is intended for registering, at intervals of 10 minutes, atmospheric pressure, atmospheric temperature, and the temperature of the registering instruments. Only drawings could be sent in, as the construction of the apparatus is not yet finished. The instrument consists of four parts, viz., the barometer, the thermometer for measuring the temperature of the instruments, the thermometer for measuring the temperature of the air, and the propelling and registering mechanism.

The barometer is a balance-barometer of simple solid structure, with supporting pillar and beam of iron.

The thermometer for indicating the temperature of the instrument is a tube, closed at the top and open below, filled with air, dipping into mercury, and balanced by a weight on a string passing over a pulley. This tube moves 2 mm. for every degree C. of change in the temperature of the instrument.

The other thermometer, intended for the measuring of the atmospheric temperature, is likewise an air thermometer, consisting of a tube similar to the above described, but which contains an iron tube, joined to a narrow lead tube (2 to 3 mm. clear width), which again is connected with the thermometer bulb. This bulb is freely exposed to the atmosphere, though protected in a proper manner against rain and sunshine. It is made of copper, has a capacity of 5 litres, and a corresponding surface area. Here, too, a change of 1° C. gives a motion of 3 mm.

Let b, t, τ, signify pressure and temperature of the atmosphere and of the instrument, x, y, z, the respective positions of the tubes I., II., and III.; then $x=f_1\,(b, \tau)$, $y=f_2\,(b, \tau)$, $z=f_3\,(b, t, \tau)$, and hence $b=\phi_1\,(x, y)$, $\tau=\phi_2\,(x, y)$, $t=\phi_3\,(x, y, z)$, that is to say, the three quantities sought are determined by the positions of the three tubes.

The movements of the tubes are communicated to rods which move vertically in front of cylinders set revolving by means of a clockwork. This same clockwork moves also hammers, which hit every 10 minutes upon the rods, whereby marks are produced upon the cylinders, and thus the positions of the tubes noted. The clockwork is specially constructed for the instrument, and the largest toothed wheel, with 120 teeth, has a diameter of 120 mm.

Before each marking the tubes are slightly moved forward by steel cylinders which dip into the mercury. All movements are produced by a horizontal axis, which completes one revolution every 10 minutes, and which is provided with the necessary wheels, &c.

Electro-magnetism is used—

(1.) To mark the hours upon the cylinders.

(2.) To work signals, which will indicate a possible stoppage of the clockwork, or other interruptions in the working of the apparatus.

(3.) To sound, by means of the clock and a bell, the hours, thus giving evidence of the right condition of all the agents employed.

The advantages of the apparatus here described are:—

(1.) The constituent agents, the balance barometer, air thermometer, and registering clockwork, are all well tested instruments. The movements to be registered are so large that it is not necessary to magnify them. They can be calculated beforehand by means of precise formulæ from constants that are easily determined with great exactness. The apparatus has, therefore, nothing of the nature of an interpolating instrument, a character belonging at present to all registering mechanisms, but must be viewed as an instrument of precision. Checking observations, *daily* required by all self-registering instruments, become superfluous with this apparatus.

(2.) The registering instruments can be put up in a dry place, protected against changes of temperature.

(3.) All parts of the apparatus are of metal and glass, wood is excluded. The instrument is, therefore, more durable.

(4.) The construction is extremely simple; any disorder is easily repaired. The purely mechanical motors are free from the disturbances to which electro-magnetic motors are so frequently subject. If moderately well executed, and tolerably well handled, the instrument will, practically, never refuse to work.

(5.) The registering of the temperature of the instrument might prove useful in other observations, since it gives the temperature of a closed space.

(6.) Not the least of the advantages is the cheapness of the instrument.

The theory of this apparatus is given in full in Volume XI. of Carl's "Repertorium für Experimentalphysik."

G. Lorenz, Chemnitz (Lachsen), has undertaken the construction of the apparatus.

2891. Kreils' Barograph, formerly in use at the Kew Observatory, for registering the movement of the barometer.

Kew Committee of the Royal Society.

An instrument employed at the Kew Observatory in 1845, for the purpose of registering automatically the height of the barometer. It consists of a syphon barometer, having a float resting upon the surface of the mercury, in the open end of the tube. Immediately above the tube a lever is fixed horizontally, and a cord, wrapped round a sector on the short arm, passes down and is attached to the float. The other end of the lever carries an ordinary pencil, which, being struck every five minutes by a hammer moved by a clock, makes a dot upon a sheet of paper fixed to a frame drawn in front of it by clockwork.

2892. Ronalds' Photo-Barometrograph, for registering photographically the changes in the height of the barometer, formerly erected at the Kew Observatory.

Kew Committee of the Royal Society.

An instrument for registering the variation in the height of the barometer upon a daguerreotype plate; constructed in 1847 by Mr. Francis Ronalds, afterwards erected at the Kew Observatory, and described by him in the British Association Report for 1851.

The light from an argand lamp, after passing through a condensing lens, falls on a narrow slit cut in a metal plate attached. A barometer tube, the mercury in which, by rising or falling, varies the length of the slit illuminated.

An achromatic combination of lenses, by Voigtlander, throws a magnified image of the bright slit upon an aperture in the case, past which a daguerreotype plate is moved slowly by clockwork, and so registers the changes in the height of the barometer.

The barometer itself, together with its cistern, which is of large area, is suspended from an arrangement of levers and zinc rods, on the principle of the gridiron pendulum, in such a manner as to render the indications unaffected by fluctuations of temperature.

An improved form of this instrument, in which the photographic image is impressed upon paper, is now in use at Kew, and at many other observatories.

2892aa. Photographic Barograph, as employed at the observatories in connection with the Meteorological Office.

Meteorological Committee of the Royal Society.

This instrument is described in the Report of the Meteorological Committee of the Royal Society for 1867. It is the improved form of Ronald's barograph, No. 2892.

2892a. Barometrograph. *M. Bréguet, Paris.*

2893. Barometer adapted to automatic registration by Photography. *Chas. Brooke, M.A., F.R.S.*

A vertical cylinder serves (as at Greenwich) for the registration of the barometer and the balanced magnetometer. *See* Magnetism.

2894. Barograph. *M. Redier, Paris.*

2895. Registering Barometer, mercurial or aneroid, showing enlarged curves without the aid of electricity or photography. *M. Redier, Paris.*

2895a. Registering Mercurial Thermometer, after the plan of M. Hervé Mangon. *M. Redier, Paris.*

2896. Barograph, balance barometer; executed by Greiner and Geissler, Joint Stock Company for manufacturing meteorological instruments at Berlin.

Imperial Admiralty Hydrographical Office, Berlin, and German Naval Observatory, Hamburg.

This instrument is put up and kept working at each of the normal observatory stations on the German coast. The stations are subordinate to the German Naval Observatory (Seewarte).

VIII.—EVAPOROMETERS.

2897. Evaporometer, in the form of a spring steel-yard.

Prof. F. Osnaghi, Imperial Central Meteorological Institute, Vienna.

This instrument shows on a sector the number of millimeters evaporated from a certain quantity of water in a given time. As its action is produced by gravity, it is also useful in winter when ice is formed on the scale. It differs from other steel-yards in the weight acting on the inner end of a spiral spring.

2898. Apparatus for determining the **Evaporation** from different soils.

Sydney B. J. Skertchly, F.G.S., H.M. Geological Survey.

The apparatus consists essentially of an evaporimeter composed of two vessels, the innermost of which receives the material to be experimented upon, and the external one supplies water to compensate for evaporation. Over this is a glass vessel which receives the vapour given off by the material. The temperature, &c., are registered by a hygrometer and barometer in the glass receiver, and the temperature of the soil by a ground thermometer. Any given temperature can be obtained by means of a platinum spiral heated by a galvanic battery. The evaporimeter maintains the material in a natural condition so far as regards temperature and moisture. Dry air is admitted into the glass receiver, and the air with the evaporated water passes from the top of the receiver into a train of drying tubes; the current of air being produced by an aspirator containing oil. By means of this apparatus various soils, &c.

can be brought under similar conditions of temperature, &c., and the evaporations compared for any temperature. The apparatus was especially designed to determine the proper amount of water which should be discharged by the artificial drainage system of the Fen Land.

2899. Integrator of Sun's Heat.

Scottish Meteorological Society.

When the water in the globe expands, some of it passes out at the bent upper tube. The level of the water is kept constant by a supply from the cistern which communicates with the globe by the india-rubber ball which acts as a valve.

Note.—The instrument, which is in principle a weight thermometer, may also be used for ascertaining the mean temperature of the air. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary.

2900. Instrument, designed to ascertain the temperatures at which visible vapour is found. *Scottish Meteorological Society.*

Water is heated in the main chamber by a lamp beneath, and its temperature is read at the point when vapour appears on one of the pieces of glass which are made to revolve slowly above the open end branch tube, and again read as the water cools, at the instant when condensation ceases to be observed. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary.

2901. Ebermayer's Evaporation Apparatus, for determining the degree of evaporation of different kinds of soil.

Prof. Ebermayer, Aschaffenburg.

The evaporating apparatus and the earth thermometer are described at greater extent in "Die physikalischen Einwirkungen des Waldes aüf Luft " und Boden," von E. Ebermayer, Aschaffenburg, 1873.

2902. Morgenstern's Atmometer. *W. Apel, Göttingen.*

Morgenstern's atmometer differs from every other by its being founded on the principles of capillarity and of Mariotte's bottle.

The evaporating vessel is filled with siliceous sand, below which there may be placed a flat stone. This sand is saturated with water by capillarity; any loss of water by evaporation is at once replaced by a corresponding volume of water from a burette. This burette forms a Mariotte's bottle, the upper part of which is closed against the outer air by means of mercury. A tube, bent in the shape of a horseshoe, of which one branch enters the burette from below, conducts air into the latter in proportion as water is lost through evaporation. When a large portion of the burette has become filled with air, the danger arises that the air column on expanding, by a possible rise of temperature, would exert a pressure upon the water below it in the burette, and thus lead to an over-saturation of the sand. To prevent this the branch of the last-mentioned tube which is placed outside the basin is provided with a small globular vessel, into which the water, pushed on by the expansion of the air column, enters. With progressing evaporation this water returns again into the burette, or can later be drawn into the burette. This globular vessel is further intended for the filling of the burette with water, which purpose is accomplished by fixing to the open end an india-rubber tube, dipping into water, and sucking at the upper end of the burette. Before the burette is completely filled the india-rubber tube is removed, and the sucking at the upper end of the burette resumed, until, in consequence, the globular vessel is emptied. The connexion of the burette with the sand is closed during the operation of filling.

The evaporating vessel has a surface area of one square decimètre.

To exclude, as much as possible, the influence of the temperature, the evaporating vessel is enveloped in some bad conducting material.

The sensitiveness of the instrument is so great that a little dry sand, or a piece of blotting paper, or the fraction of a drop of water, put upon the surface of the evaporating vessel is immediately indicated by the water column in the burette.

2903. Atmometer or Evaporometer, for determining the quantity of water evaporating from the surfaces of waters as well as from different sorts of soil. *Prof. Prestel, Emden.*

Atmidometer with Hicks' Patent enamel Stem for measuring the rate of evaporation from water, ice, or snow. *J. J. Hicks.*

The enamel stem has the divisions and figures in black on white enamel which renders the reading easy and the scale incorrosible.

2904. Apparatus for the direct determination of the tension of aqueous vapour in the atmosphere, constructed in the year 1868 by Dr. Geissler, of Bonn, according to the instructions of the late Prof. Schulze, professor of chemistry in Rostock. *Prof. Matthiessen, Rostock.*

The U-shaped tubes serve for the reception of the mercury. The absolute vapour tension of the atmospheric air enclosed in the flask-shaped vessel is directly determined, at the differential barometer, through absorption of the vapour by concentrated sulphuric acid, which is introduced for that purpose.

IX.—OZONOMETERS.

2904a. Smyth's Ozonometer, made of brass, lined with sealing-wax, and provided with brass stop-cocks, invented by contributor previous to ozonometer No. 2905. *John Smyth, jun.*

2904b. Smyth's Ozonometer, made of brass, lined with glass, and provided with glass stopper to admit air, invented by contributor previous to ozonometers Nos. 2904 and 2905. *John Smyth, jun.*

2904c. Diagram showing the rough form of *ozonometer* and *aspirator* used by contributor in his first experiments, August 1865. *John Smyth, jun.*

2904d. Diagram showing the contributor's *ozonometer* connected to Dr. Andrew's form of aspirator by means of which his later experiments have been made. *John Smyth, jun.*

2905. Smyth's Ozonometer, for the determination of the amount of ozone in a measured volume of air by means of an aspirator, invented by the contributor and described by him in a paper read at the meeting of the British Association in Birmingham in 1865. *John Smyth, jun.*

It consists of a box-wood tube or cylindrical box, about two inches long and two inches in diameter, one end of which is closed, except in the centre, where it is pierced by a quarter-inch tube communicating with the aspirator; the open end is covered by a lid or second box of the same material, which is so large as to slide over the first, and is also pierced by a quarter-inch tube, which, when the ozonometer is arranged for an experiment, directs the air against the centre of the test paper stretched across the open end of the inner or first box, and is secured there by an india-rubber band lying in a groove.

2905a. Schönbein's Ozonometer, rendered self-recording. An instrument for exposing each hour a fresh piece of Schönbein's ozone test-paper to the influence of the atmosphere. *R. C. Cann Lippincott.*

Two cylinders (one large, the other small) are enclosed in boxes, the openings of which are guarded by india-rubber lips. The boxes are 2¼ inches apart. The large cylinder is moved round 2¼ inches each hour by means of a driving-shaft attached to the clock. A strip of test-paper, about 5 ft. long and ⅝ of an inch wide, is rolled round the small cylinder, the free end of it being fastened to the large cylinder; 2¼ inches of paper are thus exposed to the influence of the atmosphere.

The clock, which goes 8 days, indicates the minutes only, and shifts the paper by causing the large cylinder to rotate 2¼ inches of its circumference exactly at the hour, thus removing the portion of paper (2¼ inches long) exposed during the past hour, and exposing a fresh portion, to be in its turn removed at the end of another hour and succeeded by a new piece, and so on. At the end of 24 hours the whole strip of test-paper is unrolled by the observer from the large cylinder, dipped, and read by the scale (Schönbein's); a fresh strip is then rolled round the small cylinder, and its free end is attached to the large cylinder as before.

The instrument was made for me by Mr. Casella, in 1868, after a plan of my own suggestion.

The following are the results of some observations made with the instrument taken from the "Proceedings of the Meteorological Society," Vol. V., p. 51.

MEAN HOURLY AMOUNTS of OZONE deduced from Observations taken every Hour (with a few omissions when the clock stopped) from Feb. 20 to Nov. 18, 1869. Test paper, Schönbein's; scale, 0 to 10.

Hours.	Midnight to 1 A.M.	1 A.M. to 2 A.M.	2 A.M. to 3 A.M.	3 A.M. to 4 A.M.	4 A.M. to 5 A.M.	5 A.M. to 6 A.M.
Mean amount of ozone - -	2·8	2·8	2·7	2·7	2·8	2·8

Hours.	6 A.M. to 7 A.M.	7 A.M. to 8 A.M.	8 A.M. to 9 A.M.	9 A.M. to 10 A.M.	10 A.M. to 11 A.M.	11 A.M. to Noon.
Mean amount of ozone - -	2·8	2·7	2·4	2·0	2·2	2·4

Hours.	Noon to 1 P.M.	1 P.M. to 2 P.M.	2 P.M. to 3 P.M.	3 P.M. to 4 P.M.	4 P.M. to 5 P.M.	5 P.M. to 6 P.M.
Mean amount of ozone - -	2·4	2·5	2·7	2·7	2·9	2·8

Hours.	6 P.M. to 7 P.M.	7 P.M. to 8 P.M.	8 P.M. to 9 P.M.	9 P.M. to 10 P.M.	10 P.M. to 11 P.M.	11 P.M. to Midnight.
Mean amount of ozone - -	2·7	2·5	2·6	2·7	2·8	2·8

Mean of all the hours = 2·63.

2906. Aspirator, with gutta percha tubing and wooden box for tests, used by the Ozone Committee during their experiments in 1869. *Scottish Meteorological Society.*

The small tin box was made by a native Arab for Dr. Arthur Mitchell, in connexion with ozone experiments made by him in Algiers in 1855.

2907. First Ozone Generator. *Dr. Werner Siemens.*

The air or oxygen to be ozonised is caused to pass between two concentric cylinders coated with tinfoil, and electrified by an induction apparatus.

2907a. Tisley's Ozone Generator. The central tube being used as a water channel, a uniform low temperature can be maintained, thereby greatly improving the per-centage of ozone. *Tisley and Spiller.*

See "Nature," 19th June 1873.

X.—MISCELLANEOUS.

2909. Plan and View of the Observatory of the Central Imperial Institute for Meteorology and Terrestrial Magnetism, Vienna.

I. R. Central Institute for Meteorology and Terrestrial Magnetism, Vienna.

The building was erected, under the direction of the Imperial Minister of Education, by the architect Ferstel, and finished in April 1872. The Observatory is provided with a great number of self-registering instruments for all observations, among which may be particularly noticed Dr. Theorell's printing meteorograph for meteorological observations, and Adie's photographical magnetometer (Kew model), for the observation of magnetic variations.

2910. Meteorological Photographs, specimens as ordinarily produced at the Radcliffe Observatory, Oxford, containing the unreduced observations made with the barograph, thermograph, hygrograph, and anemograph, by the use of the waxed paper process, from November 19th to December 6th, 1873.

Rev. Robert Main.

2911. The Storm Atlas of the Meteorological Institute of Norway, by H. Mohn. *Prof. H. Mohn, Christiania.*

"Atlas des Tempêtes de l'Institut Météorologique de Norvége, publié avec
" le concours de la Société scientifique de Christiania, par H. Mohn."

2911a. Goddard's Cloud Mirror. *G. J. Symons.*

2911b. Daily Bulletin of the Signal Service, U.S.A., May 1873. *J. Norman Lockyer, F.R.S.*

2911c. Atlas Météorologique de l'Observatoire de Paris, 1872–3–4. *J. Norman Lockyer, F.R.S.*

2912. Pane of Glass pierced by a **Hailstone** during the storm at Geneva in the night of the 7th and 8th July 1875.

Messrs. Ramboz and Schuchardt, Geneva.

This pane formed part of the roof of the printing office, in a court of the Rue de la Pelisserie, at Geneva. No thunder-bolt fell in the neighbourhood, so that this strange oval opening, the upper edge of which, it may be noticed, is blunted, cannot be attributed to the action of lightning.

2812a. Large Globe in which H. B. de Saussure collected air on the summit of Mont Blanc. With portable case or shoulder basket, capable of holding two such globes.

M. H. de Saussure, Geneva.

2913b. Dietheroscope.

Prof. Luvini, through the Meteorological Office.

2913c. Seven pictures of Clouds, according to Howard's nomenclature. *Meteorological Office.*

2913d. Meteorological Diagrams. *Meteorological Office.*

7 storm charts.
List of stations.
Colliery explosions and weather.

2914. Map of Scotland, showing the Society's stations, the prevailing winds, and the annual rainfall. *Scottish Meteorological Society.*

The present stations are indicated by a *black* circle, and stations at which observations are no longer made by a *circle and a cross.* Rainfall stations by a *red* circle. Constructed by Alexander Buchan, M.A., F.R.S.E., Secretary.

2915. Temperature of the British Islands, for each month and for the year. *Scottish Meteorological Society.*

On all the maps the isothermals up to 44° are coloured *black;* those from 45° to 54° are coloured *blue;* and those from 55° and upwards are coloured *red.* Prepared by Alexander Buchan, F.R.S.E., Secretary, and published in the Society's Journal, vol. iii. p. 102.

2916. Seasonal Distribution of the Rainfall of Europe, showing the month of *greatest* rainfall and the month of *least* rainfall of its different regions. *Scottish Meteorological Society.*

The months from November to February are coloured *blue;* from March to May, *green;* from June to August, *red;* and September and October, *black.* Prepared by Alexander Buchan, Secretary.

2917. Charts, showing the mean monthly and annual amount of the diurnal oscillation of the barometer over the globe, from the a.m. maximum to the p.m. minimum, by lines of 10, 20, 40, 60, 80, and 100 (and upwards) thousandths of an inch (0·010, 0·020 inches, &c.). *Scottish Meteorological Society.*

The portions shaded *red* indicate an oscillation of 0·100 inch and upwards. Prepared by Alexander Buchan, Esq., F.R.S.E., Secretary of the Society, and published in Trans. Roy. Soc. Edin., vol. xxvii. p. 397.

2918. Charts, showing by isobaric lines the mean pressure of the atmosphere, and by *arrows* the prevailing winds over the globe for each month. *Scottish Meteorological Society.*

Isobarics of 30 inches and upwards are coloured *red,* and those under 30 inches *blue.* Thus the red isobarics indicate where pressure is in excess, and the blue isobarics where the pressure is in defect.

Calms are marked with a circle, and variable winds with an asterisk. The arrows fly with the wind.

Constructed by Alexander Buchan, F.R.S.E., and published in Trans. Roy. Soc. Edin., vol. xxv., p. 575.

2919. Diagrams, showing for London the influence of weather on mortality from different diseases and at different ages. No. I. *Scottish Meteorological Society.*

Mortality classed according to—

A. Age (average of 5 years).—Under 5 years coloured *red;* 5 to 40, *blue;* 40 and upwards, *black.*

B. Sex (average of 30 years).—Males coloured *red;* females, *blue.* The weekly deviations from the mean line are given in per-centages above and below the average.

C. Groups of diseases (average of 30 years).—The upper *thin* line represents weekly averages from all causes of death whatever; and the *thick black* line, from all causes minus violent deaths. The *red* space embraces deaths from all bowel complaints; and it will be observed that the subtraction of these diseases takes away the summer maximum from the general curve. The *blue* space embraces all diseases of the respiratory organs; and the *dark* space, diseases of the brain and consumption.

The mean weekly temperature is represented by the *red* line.

Prepared by Alexander Buchan, Secretary, and Dr. Arthur Mitchell, Chairman of the Medico-climatological Committee, and published in the Society's Journal, vol. iv., p. 187.

2920. Diagrams, showing the influence of weather on mortality from different diseases and at different ages. Nos. II. and III. *Scottish Meteorological Society.*

D. Showing mortality curves from special diseases, viz., small-pox, measles, whooping-cough, scarlet fever, typhus and typhoid fevers, erysipelas, metria, rheumatism, pleurisy, and pericarditis.

E. Showing mortality from bowel complaints, viz., dysentery, British cholera, cholera, and diarrhœa.

F. Mortality from diseases of the respiratory organs, viz., asthma, bronchitis, pneumonia, and laryngitis.

The curves under D, E, and F are the averages of 30 years, and the deviations from the mean lines are given in per-centages above and below the average.

Prepared by Alexander Buchan, Secretary, and Dr. Arthur Mitchell, Chairman of the Medico-climatological Committee, and published in the Society's Journal, vol. iv., p. 187.

2921. Diagrams, showing the mortality of British large towns. No. I. shows the weekly mortality from *all causes* for large towns of England, and No. II. for large towns in Scotland and Ireland. The averages are in most cases 10 years. The weekly averages are calculated at the annual rate of mortality per 1,000 of the population. *Scottish Meteorological Society.*

The mean annual mortality per 1,000 of the population of each town is given in the left-hand margin. The *red* lines show the deviations from this average for each week of the year.

No. III. shows the weekly mortality from *diarrhœa* for large towns of England, and for Edinburgh. The averages are in most cases for 10 years. The weekly averages are calculated at the annual rate of mortality per 1,000 of population. The breadth of space coloured red shows, for each week, the rate of fatality for each town.

Prepared by Alexander Buchan, Secretary, and published in the Society's Journal, vol. iv., p. 337.

2922. Diagram, showing the *steadiness* of the mortality curve of scarlet fever in each of the six epidemics which have occurred in London from 1840 to 1874. *Scottish Meteorological Society.*

A. represents the per-cent. of deviation from the mean line of each week's average of each of the six epidemics. The duration of each epidemic is given on the left-hand margin, and its average weekly death-rate on the right-hand margin.

B. shows the gross mortality for each year of the period, each epidemic being marked by a different colour.

By Arthur Mitchell, M.D., F.R.S.E., Chairman of the Medico-climatological Committee. Published in the Society's Journal, vol. iv., p. 340.

2923. Diagram, showing for London the relation of diarrhœa to temperature. *Scottish Meteorological Society.*

A. represents the mean temperature of 1859, having the hottest summer in London from 1845 to 1874; of 1860, having the coldest summer during the same period; and of 1861, having an average summer temperature.

B. represents the mean weekly death-rate in London from diarrhœa during each of these same years, the colours of the diarrhœa curves corresponding with those of the temperature curve for the same years. The weekly death-rate has been calculated in each case at the annual rate of 1,000 of the population.

By Arthur Mitchell, M.D., F.R.S.E., Chairman of the Medico-climatological Committee.

2924. Barometric Gradients.

Scottish Meteorological Society.

Model illustrative of the principle of the barometric gradient, which is calculated by dividing the distance between any two barometers by their difference in reading, both being reduced to 32° and sea level (or the same level). Designed by Thomas Stevenson, C.E., Honorary Secretary, and described in the Society's Journal, 1867, when the proposal was first made.

2925. Drawing of an instrument for ascertaining sea and river temperature by thermometers continuously immersed.

Scottish Meteorological Society.

The case containing the instruments is suspended from the pier, or lightship or in the river, and is drawn up bringing with it some water in the cistern at the bottom, in which the thermometer bulbs are placed. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Society's Journal, vol. iv., p. 44.

2926. Cloud Reflecting Compasses. For ascertaining direction of higher currents of air.

Scottish Meteorological Society.

When a cloud is to be observed the compass should be turned round till one of the hues on the mirror coincides with a well defined edge of the cloud, and the compass is then made to revolve, gradually keeping the hue constantly on the edge of the cloud. The angle indicated by the magnetic needle being afterwards read off, the direction of the cloud's motion in azimuth is at once ascertained. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Edinburgh Philosophical Journal, 1855.

2926a. Hypsometric Map of the Caucasus, recently published by the Topographical Office at Tiflis.

The Pulkowa Observatory.

2926b. Diagrams Illustrative of Underground Temperature. *G. J. Symons.*

2927. Graphic Representations of Underground Temperatures in Fifeshire, by Sir J. Leslie. *University of Edinburgh.*

2928. Graphic Representations of Underground Temperatures near Edinburgh, by Principal Forbes.

See Trans. Roy. Soc. Edin., 1846, for a full account of each. *University of Edinburgh.*

2928a. Map of the **British Isles,** showing sites at which rainfall observations are being made. *G. J. Symons.*

2928b. Engravings of various apparatus employed in rainfall experiments. *G. J. Symons.*

2928d. Diagram showing the fluctuations of rainfall in central England, from 1726 to 1869. *G. J. Symons.*

2928e. British Rainfall. On the distribution of rain over the British Isles during the year 1874, as observed at about 1,700 stations in Great Britain and Ireland, with maps and illustrations. *G. J. Symons.*

2928f. Monthly Meteorological Magazine. *G. J. Symons.*

2928g. Rain ; How, When, Where, and Why it is measured ? Being a popular account of rainfall investigations. *G. J. Symons.*

2928h. Series of Blocks to illustrate the production of *weather charts* in *newspapers,* as carried out by the Patent Type Founding Company.

The Meteorological Committee of the Royal Society.

1. Plaster block, with outline of land.
2. Do. engraved by drill pantograph.
3. Cast of No. 2 in fusible metal.
4. Mould from No. 3 in papier mâché.
5. Cast from No. 4 in type metal.
6. Proof from No. 5.

2929. Meteorological Stand, with Psychrometer case, as used in the Imperial Navy. *C. Bamberg, Berlin.*

2930. Case for the exhibition of telegrams and weather reports of the Naval Observatory at the signal stations on the German coast.

Imperial Admiralty Hydrographical Office, Berlin, and German Naval Observatory, Hamburg.

2931. Meteorological Window-stand, Reinert's system for the stations of the German Naval Observatory.

Imperial Admiralty Hydrographical Office, Berlin, and German Naval Observatory, Hamburg.

The case contains a psychrometer and a thermograph (minimum and maximum thermometer); it is kept at a proper distance from the window, and when in this situation the sliding door is closed; on bringing it nearer to the window, for the purpose of reading off the indications, the door opens automatically.

2932. Collection of Weather Maps of the German Naval Observatory, for the month of March 1876.

Imperial Admiralty Hydrographical Office, Berlin, and German Naval Observatory, Hamburg.

2933. Storm Warner and Weather Indicator, original instrument, 0·85 in. long and 0·50 in. broad.

Annexed to the same is a treatise entitled: "Der Sturmwarner " und Wetteranzeiger, ein nach wissenschaftlichen Grundsätzen " ausgeführtes und durch Beobachtung und Erfahrung bewährtes " Instrument zur Vorherbestimmung von Sturm und Wetter."

Prof. Prestel, Emden.

2934. Graphical Representation of the changes of the weather in the years 1857, 1858, and 1859.

Prof. Prestel, Emden.

2935. Diagram of Solar Spots and their connexion with the variations of magnetic declination.

Prof. Rod. Wolf, Zürich.

The upper black curve gives the monthly relative numbers, introduced by him, for the years 1831–1875; the red one their means from twelves to twelves. The lower black curve gives the corresponding yearly relative numbers for the years 1745–1875; the red curve their reduction to the scale of the variation of magnetic declination at Prague. To the last curve are added (in black colour) those obtained from observation of the variation of magnetic declination at Mannheim, Paris, London, Göttingen, and Prague, demonstrating the connexion between the frequency of the solar spots and the variation of magnetic declination.

2937. Shortrede's Barometric Slide Rule, as arranged by Major-General A. De Lisle, R.E., for barometric readings and boiling points. *Elliott Brothers.*

The barometric scale is calculated from Bailey's formula. The range extends to about 15,000 feet of altitude, occupying the three faces of the slides. The back has logarithmic lines for computing the corrections, scales of which are given on the edges. The method of using the lines is given on the face of the rule. The corrections are: 1st, for temperature of mercury; 2nd, for temperature of air; and, 3rd, for latitude. Aneroids only require the two last. This rule was invented by the late Major-General Shortrede, formerly of the Great Trigonometrical Survey in India.

The logarithmic slide solves the following equations:—

$$x=ab\,;\; x=\frac{a}{b}\,;\; x=\frac{ab}{c}\,;\; x=\frac{c}{ab}$$

$$x=a^2\,;\; x=\frac{a^2}{c}\,;\; x=\frac{c}{a^2}$$

2938. Thermometer Screen for meteorological stations of the 2nd order. In use at the stations of the Norway Meteorological Institute. *Prof. H. Mohn, Christiania.*

Made of plate iron. To be mounted outside a window and kept in shade. The screen contains one psychrometer (dry and wet bulb), one minimum thermometer (both instruments made by R. Grave in Stockholm), and one hair-hygrometer (made by Herman and Pfister in Bern). The screen is constructed after the designs of Prof. H. Mohn.

2939. Thermometer Screen for one single thermometer for obtaining the temperature of the air. In use at stations belonging to the Norway Meteorological Institute.

Prof. H. Mohn, Christiania.

Made of plate iron. To be mounted outside a window or on a wall, and kept in shade. With thermometer, made by R. Grave, in Stockholm. Screen constructed after the design of Prof. H. Mohn.

2940. Thermometer Screen for one minimum thermometer. In use at stations belonging to the Norway Meteorological Institute. *Prof. H. Mohn, Christiania.*

Made of plate iron, with double walls. Suspended on a cylindrical rod intended to pass through the window-frame. The rod has a handle inside, so that the screen with the thermometer can be turned for "setting" in the same way as a thermograph. The double walls prevent the rising of the thermometer, even in direct sunshine, to more than a few degrees above the temperature of the air. The minimum thermometer is made by R. Grave, in Stockholm. The screen is executed after designs of Prof. H. Mohn.

2941. Stevenson's Box for Thermometers.

Scottish Meteorological Society.

The box is louvre-boarded, and painted white inside and outside, and screwed to four stout posts, also painted white, firmly fixed in the ground. The posts must be of such a length that when the thermometers are hung in position the bulbs of the minimum thermometer, and of the dry and wet bulb thermometers, will be exactly at the same height of 4 feet above the ground, the maximum thermometer being hung immediately above the minimum thermometer. The thermometer box is to be placed over a plot of grass, and in a free open space to which the sun's rays have free access during as much of the day as surrounding conditions enable the observer to secure. The thermometers are suspended on cross-laths in the centre of the box, and face the door, which should open to the north.

Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, and described in the Society's Journal, vol. i., p. 122.

2942. Plunging Apparatus, by "Baudin," for observations at sea, with maxima air-bubble thermometer of "Walferden," and minima vertical thermometer of "Baudin," withdrawn from external pressure. *M. Baudin, Paris.*

2942a. Model, illustrative of Meteorological Sections of the atmosphere. *Scottish Meteorological Society.*

Showing vertical gradient for temperature, pressure, humidity, &c., ascertained by dividing the difference of readings between the instruments at the two heights by the height between them. Designed by Thomas Stevenson, C.E., F.R.S.E., Honorary Secretary, described at a general meeting of the Society, and published in "Nature."

2942b. Maps of the **Distribution** of **Temperature** over the **British Islands.** *Prof. Hennessy, F.R.S.*

Maps derived from the results of observation and showing the distribution of temperature in the British Islands as illustrative of the law of distribution in islands whose coasts are bathed by heat-bearing currents. See the "Atlantis" for June 1858, and the "Philosophical Magazine," 1858.

2942b. Proceedings and Transactions of the Meteorological Society of Mauritius. Vol. vi.
The Royal Commissioners for the International Exhibition of 1851.

Monthly notices of same Society.

Contributions to the Meteorology and Hydrography of the Indian Ocean, Part I.

1 Vol. of Weather Charts, Indian Ocean, 1861.

2 Charts showing the number and tracks of the cyclones in the Southern Indian Ocean.

SECTION 15.—GEOGRAPHY.

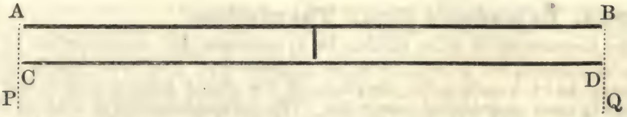
WEST GALLERY.—ROOMS L. AND M.

I.—SURVEYING INSTRUMENTS.

COLLECTION OF INSTRUMENTS LENT BY THE ORDNANCE SURVEY.—MAJOR-GENERAL CAMERON, R.E., C.B., F.R.S., DIRECTOR-GENERAL.

2943. Colby's Compensation Bars.

The first operation in an extensive survey, viz., the measurement of a base line, is beset with many difficulties, one of the greatest of which arises from the fact that the lengths of the measuring rods, bars, or chains vary with the temperature. This could be got over if one could ascertain at any moment the precise temperature of the rods, bars, or chains, but it is not easy to be assured on this point. Hence arose the idea of a compensation apparatus which was carried out by Major-General Colby, at the commencement of the survey of Ireland, in the following manner. Two bars of different metals and different rates of expansion are laid parallel and close to each other as AB, CD—



They are firmly connected at the centre, from or to which point they are free to expand or contract. At a given temperature they are taken of the same length, and in this state suppose lines ACP BDQ to be drawn through their extremities, so that AP = BQ, make also the ratio of AP to CP and of BQ to DQ, equal to the ratio of the expansion of the bar AB to that of the bar CD. Now, if we suppose both bars to receive an equal increment of temperature, and in this position lines to be drawn through their extremities, these lines will pass through the points P, Q.

The compensation bar, then, consists of a bar AB of brass, united at its middle to an equal bar CD of iron; at each extremity of the bars is a metal tongue, connected with them by pivots. These pieces are about six inches in length, and on a silver plug at the extremity of each is a finely engraved dot. The dots are 10 feet apart at all temperatures.

When used in measurement of a line, the dots on two adjacent bars are brought to the precise distance of six inches apart by means of a compensation microscope. The compensation microscope is formed by uniting two ordinary microscopes by parallel bars of iron and brass, in such a manner that their outer foci are "compensated," and measure six inches whatever may be the temperature. The whole apparatus consists of six bars and seven microscopes, of which two bars and three microscopes are now exhibited.

Two base lines have been measured with this apparatus, one in the north of Ireland, in 1827, and the other on Salisbury Plain, in 1849. Upon these two lines depend all the results of the trigonometrical survey.

2944. Ramsden's Theodolite.

This instrument was made by the celebrated Ramsden, and first used in 1792. Since that time it has been in use at a vast number of stations, including the highest mountains in England and Scotland, the Hebrides, Orkney, and Shetland. It is now in as good condition as when it was first made, having never in all its travels met with any accident or ill-usage. Subsequent to the year 1843, the observations with it have been made by non-commissioned officers of the Royal Engineers. This instrument is a slight improvement on another made by Ramsden,—the 3-ft. theodolite of the Royal Society,—which was completed and first used in July 1787, but the two are almost identical. The divisions of the circle on the Ordnance Theodolite are rather closer than in the Royal Society's. The focal length of the telescope is 36 inches, and the aperture 2·5 inches, the magnifying power ordinarily used 54. The probable error of a single observation of a fine object under favourable circumstances is about 0·18″. The astronomical determination of the direction of the meridian has been effected at many stations with this instrument. In 1862 it was used at Fairlight, near Hastings, and St. Peter's Church, Isle of Thanet, in the extension of the English Triangulation into France and Belgium.

Many of the observations made with this theodolite have been to points upwards of 100 miles off (seen by means of a heliostat, a looking-glass reflecting the sun's light). The greatest distance ever observed was 120 miles, from Ben More in South Uist to a hill in Sutherlandshire.

The diameter of the circle of this instrument is 36 inches. The weight of the whole is 200 lbs.

2945. Ramsden's Small Theodolite.

This instrument is very similar in appearance and construction to the large instrument, but is only 18 inches in diameter. The focal length of the telescope is 19·5 inches, the aperture of the object glass 2 inches, and the ordinarily used magnifying power 30. The horizontal circle is read by three microscopes.

It has been used at a very large number of stations, many of them being church towers and spires. At Thaxted Church, of which the tower is 79 feet high, surmounted by a spire of 93 feet, the instrument was 178 feet above the ground. It was also used at St. Paul's Cathedral, over the cross. At one of the stations in the north of France, some 14 miles east of Boulogne, this theodolite was mounted on a scaffolding 75 feet high.

2946. Troughton and Simms' 24-Inch Theodolite.

This theodolite, of a totally different construction from Ramsden's, was made by Messrs. Troughton and Simms, at the commencement of the Irish Survey. In Ramsden's theodolites, the divided horizontal circle revolves with the telescope, while the microscopes which read it are fixtures. In Simms', the microscopes are connected with the telescope, and rotate with it, while the circle is fixed.

The focal length of the telescope is 27 inches, and the aperture 2·125 inches. The instrument has a repeating table, and is, strictly speaking, an altazimuth. The horizontal circle is read by five micrometer microscopes.

It has been in continual use, at a very large number of stations, from 1829 until 1862, and, like Ramsden's theodolites, has been so fortunate as to escape accidents.

2947. Troughton and Simms' 14-inch Theodolite.

This instrument is one of excellent construction. The telescope has 2 inches aperture and 18 inches focal length, the ordinary magnifying power 40. The horizontal circle is read by three micrometer microscopes: the vertical circle by two micrometer microscopes. It is admirably suited for astronomical observations. It is, comparatively with the other theodolites exhibited, a new instrument.

2948. Airy's Zenith Sector.

This instrument was used between the years 1842 and 1850 in the determination of the latitudes of 27 stations of the principal triangulation of the kingdom. On the destruction of Ramsden's Zenith Sector in the great fire at the Tower of London this instrument was invented and constructed under the direction of the Astronomer Royal, Sir George Airy. The first principle in the instrument is the arrangement for making successive observations in two positions of the instrument, face east and face west, at the same transit of a star. The second principle was the substitution of a level or system of levels for the previously used plumb-line. The third principle was the casting in one piece, as far as practicable, of each of the different parts of the instrument, in order to avoid the great number of screws and fastenings with which most instruments are hampered, and to secure if possible perfect rigidity.

The focal length of the telescope is 46 inches, the aperture 3·75, and the magnifying power 70. The vertical arc is read by four micrometer microscopes.

The weight of the entire instrument is rather more than half a ton.

2949. Zenith Telescope.

This instrument has done much service in North America and in Scotland in the determination of latitudes. It is most simple in its construction, consisting of little more than a good telescope capable of being set to any zenith distance, and rotating round a long and very firm vertical axis. In the focus of the eyepiece, besides five ordinary transit wires, is a micrometer wire, adapted to measurement of zenith distance, to the extent of 45′. The mode of using the instrument is this: suppose two stars pass the meridian at nearly equal zenith distances, and within a few minutes of one another in point of time, the one star being to the north, the other to the south of the zenith; the observer sets the telescope for the first star (of course in the plane of the meridian), reads the micrometer wire, rotates the instrument 180° round the vertical axis, and looks for the second star: as it passes through the field he bisects it with the micrometer wire. The difference of the reading of the micrometer on the two stars leads to the immediate knowledge of the latitude; the indications of the level being of course taken into account. This instrument was made by Wurdemann of Washington, United States, America, for the North American Boundary Commission: it is a great favourite with observers, and certainly leads to the most excellent results.

2950. Portable Transit Instrument.

The small transit instrument exhibited has a telescope of 21 inches focal length and 1·7 inches aperture. The uprights are of mahogany. The telescope is provided with a reversing apparatus.

2951. Clinometer.

For determining the values of levels, such as are used in the zenith sector, zenith telescope, and other astronomical instruments. The two micrometer screws at the right hand of the instrument are moved simultaneously. The value of one division of these screws corresponds to a change of inclination of the upper bar, of one second of angle.

2952. Standard Toise.

This bar of cast steel was formed to be a connecting link between the English yard and the "toise," which is the geodesic unit of length of so many countries of Europe. Its length in terms of the standard yard (about 76·74 in.) is known, from some 4,000 observations, with a probable error of one ten-millionth part of itself. It has been compared with the standard toise of Belgium, with that of Prussia, with the standard double toises of the Russian Geodetic Survey, with a standard toise of Vienna, and with the Spanish four-metre bar.

Connecting the survey of so many countries, this standard bar takes a place of the utmost importance in the determination of the figure of the earth.

The continental toises are generally measures "by contact;" that is, the measure is not indicated by lines on the bar, but by the entire length of the bar between its extremities.

2953. Thermometer Calibration Apparatus.

It is necessary in the comparisons of standards that the errors of the thermometers should be known to two or three hundredths of a degree Fahrenheit. The calibration errors of the best standard thermometers (such as those made by Casella for the Ordnance Survey) are extremely small, but it is necessary to determine what they actually are in order to correct the observations made with them. The apparatus consists of a cast-iron frame, having two parallel rods above, on which slides a microscope. The thermometer lying in a carriage below is read by the microscope, and by means of the micrometer screw on the right a small movement is communicated to the carriage and thermometer. Now, if we break off from the column of mercury a piece, say of 30° in length, and cause that piece to take different positions in the tube, it will be seen that we can by means of the micrometer and the microscope detect errors among the division lines; and finally, by using columns of various lengths, determine as many errors as we choose.

2954. Isometric Drawing of Expansion Apparatus.

This drawing shows the interior of the room in which the comparisons of bars are made; it is a room 20 feet by 11, half sunken below the surface of the ground, and entirely surrounded and covered over by an outer building. In the drawing are shown the three stone piers for carrying microscopes. In the experiments depicted, two microscopes are used and stand upon the outer piers. The long boxes contain bars, one hot, the other cold; they are alternately brought under the microscopes. In this manner the absolute expansions of two Indian standards, two English standards, and two American standards have been determined. The drawing shows the flexible tubes which form supply and waste pipes for the currents of water, hot and cold, which maintain the bars at steady fixed temperatures.

Surveying Instruments exhibited by the Ordnance Survey Department of the Royal Prussian General Staff, Berlin.

2955. Distance and Angle Measuring Telescope Ruler

(Kippregel), old construction, by Breithaupt, No. 71.

2956. Distance and Angle Measuring Telescope Ruler (Kippregel), construction of 1874, by Breithaupt, No. 97.

2957. Distance and Angle Measuring Telescope Ruler (Kippregel), construction of 1875, by Sprenger, No. 108.

2958. Surveyor's Plane Table, old construction, by Baumann, No. 53.

2959. Surveyor's Plane Table, improved construction, by Baumann, No. 82.

2960. Surveyor's Plane Table, construction of 1874, by Breithaupt, No. 91.

2961. Surveyor's Plane Table, construction of 1875, by Sprenger, No. 113.

2962. Two Surveyor's Plane Tables. Prepared for surveying.

2963. Two Surveyor's Plane Tables.

2264. Distance Staff.

2965. Universal Instrument, latest construction.

With such instruments as these the topographical survey of Prussia is carried on. The Trigonometrical Department of the Royal Survey lays down the network of triangles, and gives the geographical longitude, latitude, and elevation of each individual trigonometrical point to the Topographical Department, in a similar form to that shown in No. 2962. This sheet (section Kalisch) contains the trigonometrical points which are marked thus "⊕," the station being at the point of intersection of the two lines. The minute network drawn upon the sheet is on the scale of 1:25,000, to which the topographical surveys are executed.

The surface covered by each section between 54° and 55° N. lat. amounts to about 2·2 square (German) miles.

The position of the square in the sections in relation to the degree net is shown by the two general tables appended to No. 2962. Here the section Kalisch is coloured red.

The *Universal Instrument* (2965) is one of the instruments used for measuring the angles of the triangles of the *first* order by the Trigonometrical Department of the Royal Land Survey. The one here exhibited was taken out to Kerguelen's Land by the expedition for observing the transit of Venus.

SECRETARY OF STATE FOR INDIA.

PHOTOGRAPHS OF INSTRUMENTS USED FOR THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

2966. Photographs of the Great Theodolite for the great trigonometrical survey of India. Designed by Lieut.-Colonel A. Strange, F.R.S.

Constructed by Messrs. Troughton and Simms. Telescope, aperture $3\frac{1}{4}$ inches, focus $36\frac{1}{4}$ inches. Horizontal circle, diameter 3 feet. Vertical circle, 2 feet. (Photograph about $\frac{1}{8}$ real size.) No. 1. General perspective view. No. 2. Elevation in plane of pillars. No. 3. Side elevation, showing vertical circle and microscopes. No. 4. Side elevation, showing counterpoises of vertical circle and microscopes. No. 5. Horizontal circle (plan of upper surface). Vertical axis socket. Horizontal microscope arms, &c. (plan of under surface). No. 6. Horizontal circle (plan of under surface). Table, pillars, horizontal microscope arms, &c. (plan of upper surface).

2967. Photographs of the Zenith Sector for the great trigonometrical survey of India. Designed by Lieut.-Colonel A. Strange, F.R.S.

Constructed by Messrs. Troughton and Simms. (Telescope, aperture 4 inches, focus 4 feet. Sector, diameter 3 feet.) (Photograph about $\frac{1}{8}$ real size.) No. 1. Front elevation, complete. No. 2. Front elevation, telescope and sector removed. No. 3. Back elevation, complete. No. 4. Side elevation, complete. No. 5. Telescope and sector (side elevation). Plinth (plan of inner surface). Vertical axis. Cradle, with microscopes and levels (plan).

2968. Photographs of the Electro-Chronograph for the great trigonometrical survey of India.

Constructed by M. Eichens and M. Hardy, of Paris, under the superintendence of Lieut.-Colonel A. Strange, F.R.S., assisted by M. Leon Foucault, member of the Institute. (Photograph about $\frac{1}{8}$ real size.) No. 1. Front elevation. No. 2. Back elevation. No. 3. End elevation, showing clockwork. No. 4. End elevation, showing connexion of pointer slide with barrel. No. 5. Plan of upper surface-barrel removed.

2969. Photographs of the Transit Instrument for the great trigonometrical survey of India. Designed by Lieut.-Colonel A. Strange, F.R.S.

Constructed by Messrs. T. Cooke and Sons. Telescope, aperture 5 inches, focus 5 feet. (Photograph about $\frac{1}{12}$ real size.) No. 1. General perspective view. No. 2. Elevation in plane of telescope. No. 3. End view of transit axis and levels. No. 4. Front view of transit axis and levels. Bearings and their foundation plates (plan of upper surfaces). No. 5. Bearings and their foundation plates (side and inner elevations).

2970. Photographs of the Diagonal Transit Instrument for the great trigonometrical survey of India.

Constructed by Messrs. T. Cooke and Sons, under the superintendence of Lieut.-Colonel A. Strange, F.R.S. Telescope, aperture 2·64 inches, focus 34·6 inches. (Photograph about $\frac{1}{6}$ real size.) No. 1. Elevation in plane of telescope. No. 2. Telescope raised for reversal.

2971. Photographs of the Vertical Circle for the great trigonometrical survey of India.

Constructed by M. M. Repsold, of Hamburg, under the superintendence of Lieut.-Colonel A. Strange, F.R.S. Telescope, aperture 1·9 inch, focus 18·8 inches. Vertical circle, diameter 12 inches. (Photograph about $\frac{1}{8}$ real size.) Front and side elevations.

II.—HYDROGRAPHY.

ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

DEEP-SEA SOUNDING AND DREDGING APPARATUS, AND SURVEYING INSTRUMENTS, USED IN H.M.S. "CHALLENGER," 1872–6. EXHIBITED BY THE HYDROGRAPHICAL DEPARTMENT, ADMIRALTY.

2971a. Altitude and Azimuth instrument, 8-inch.

Repeating circle.

Theodolite, 6½-inch.

Sextant, observing.

Sextant, sounding.

Sextant, pocket, or box.

Micrometer telescope, 24-inch.

Station pointer, 6-inch.

Protractor, circular. (Bullock.)

Protractor, semi-circular.

Protractor, rectangular, 12-inch. (Metal.)

Protractors, rectangular, 8-inch. Case of three.

Scale, brass, graduated, 3 feet.

Straight-edge, steel, 6 feet.

Parallel rulers, 12, 18, and 24 inch. Case.

Sector. (Metal.)

Mathematical instruments. Case.

Baillie weight detaching apparatus, date 1872. By Nav. Lieutenant C. W. Baillie, R.N.

Hydra weight detaching apparatus, date 1868. By Gibbs, Artificer, H.M.S. "Hydra."

Tube lead, 1 cwt. For sounding in depths not exceeding 1,000 fathoms, and procuring bottom specimen, date 1872.

Cup lead, 1 cwt. For sounding in depths not exceeding 1,000 fathoms, and for procuring bottom specimen, date about 1858.

Sounding ring and rod, fitted with wire.

Sounding weights, $\frac{1}{2}$ cwt.

Dredge, medium size, complete with net.

Trawl, with beam and irons.

Dredge rope, 5 fathoms of 3-inch.
" " $2\frac{1}{2}$-inch.
" " 2-inch.

Sounding line, 5 fathoms.

Accumulators, one set. For easing the strain, upon dredge rope or sounding line, caused by the motion of the ship.

Gin block, 9-inch, patent. For attaching to accumulators.

Slip Water Bottle, for obtaining specimen of bottom water, is a brass rod, with three radiating plates to strengthen it and act as a guide for the brass cylinder which encloses the water. At the bottom and half-way down the radiating plates are finely-ground sections of cones, upon which the upper and lower surfaces of the cylinder accurately fit. Over the notch of the tumbler at the top of the brass rod is placed the bight of a line which suspends the cylinder over the cones while the bottle is descending, and which is released by the tumbler falling over, when the strain is removed, by the instrument reaching the bottom, thus allowing the cylinder to fall on the cones and enclose the bottom water. A tap at the bottom of the bottle facilitates withdrawing the water.

Stop-cock Water Bottle, for obtaining specimens of water at different depths, consists of a brass tube, with stop-cock and bell-shaped mouth at either end. Each stop-cock has a lever attached to the brass side-rod in such a manner that the movement of the rod opens or closes the cocks simultaneously. The brass plate, hinged on a stud near the top of the side-rod, is so arranged that, while the bottle is descending and the water passing freely through, it remains in a vertical position. On the sounding line, to which the bottle is attached, being checked, the plate assumes a horizontal direction, and on heaving up, the pressure of the water on the plate closes both stop-cocks; a still greater pressure is sufficient to release the plate from the spring, which retains it in position when it falls down in a line with the side-rod. A small tube, with spiral spring, in the upper part of the bottle, allows the water to expand.

Tow Net.

Set of Sieves, for sifting mud dredged from the bottom.

INSTRUMENTS COMPRISED IN THE ORDINARY OUTFIT OF ONE OF H.M. SHIPS EMPLOYED ON SURVEYING SERVICE.

2972. Azimuth and Altitude Instrument.

2973. Theodolite, 5-inch.

2974. Sextant, observing, and stand.

2975. Sextant, used for measuring angles between terrestrial objects, to fix the position of a ship or boat when engaged in sounding.

2976. Sextant, pocket or box.

2977. Artificial Horizon, roof.

2978. Artificial Horizon, black glass, portable. Used in travelling.

2979. Micrometer Telescope. Rochon. Invented by the Abbé Rochon. Date 1812. Used (in surveying) for the measurement of distances by means of a base a few feet in length.

It is formed of two prisms of rock crystal, the one cut parallel to the axis of the crystal, and the other parallel to one of the faces of the pyramid; these are placed one on the other in contrary directions, and cemented together in a cell which slides in the body of the telescope, and by means of a slit in the direction of its length, so that the prism may be moved along the tube by means of the index, and a milled head screw, which is connected with the prism-box inside.

The scale on the telescope tube is divided into minutes of arc, and by means of a vernier, reading to seconds.

A table accompanies the instrument, giving the distances for the angular measurement of each foot of base.

2980. Heliostat. A mirror for reflecting the sun's rays, used in trigonometrical surveys to indicate, from great distances, the position of a station.

2981. Station Pointer, 6-inch. For placing the observer's position on the chart from angles taken between three objects, the relative positions of which are known.

2982. Protractor, circular, with arms. For projecting the angles of a survey.

2983. Protractor, circular. Bullock.

2984. Protractor, semi-circular.

2985. Protractor, rectangular.

2986. Protractor, horn.

2987. Parallel Rulers.

2988. Scale, brass, graduated.

2989. Scales, ivory ; set of 6.

2990. Beam Compass, wood. For the accurate measurement of long sides in projecting triangulation.

2991. Drawing Instruments ; magazine set.

2992. Drawing Instruments, for service in boats.

INSTRUMENTS OCCASIONALLY FURNISHED TO OFFICERS ENGAGED IN NAVAL SURVEYING EXPEDITIONS.

2993. Reflecting Circle. Troughton.

2994. Sextant, Travelling, small.

2995. Sextant, Observing, with micrometer and indicators. Davis.

2996. Sextant, Sounding, Double. Beechey.

2997. Sextant, Pocket, Double. George.

2998. Dip Sector. By Troughton. For measuring the angle between the apparent and true horizons, from an elevation above the surface of the earth.

2999. Artificial Horizon, portable. George.

3000. Stadiometer. Blakey. An ordinary telescope fitted with a sliding measure and linear arrangement on object-glass ; designed for the purpose of determining the distance apart of two ships, the height of the masthead of the second ship being known.

3001. Optical Opposite. Raper. An instrument for determining and preserving a position in a direct line between two objects.

3002. Beam Compasses, tubular.

3003. Beam Compasses, bar, metal.

SOUNDING MACHINES AND APPARATUS USED BY H.M. SHIPS IN DEEP SEA EXPLORATION.

3004. Clam, for bringing specimens of the sea bottom. Sir John Ross; date 1818. Designed and used by Sir John Ross in H.M.S. "Isabella" in Baffin Bay.

The claw is kept open by hinged arms within ; whilst thus open, the outer case is kept up, and a spike connected with the arms projects below the claw. On striking bottom the spike forces the arms up ; this releases the outer case ; as the claw closes, the case slides down, and the contents in claw are secured.

3005. Brooke's Rod, for bringing up specimens of the sea bottom, and weight detaching apparatus (about 1856). By Mr. Brooke, Midshipman, United States Navy. Used, with various modifications, to 1868.

In the first instrument employed in the United States Navy the valve securing the specimen of the sea bottom was not applied, quills being inserted in the tube for that purpose. The hook, with the wire and ring, supports the sinker weight as long as there is strain on the sounding line; the moment that strain ceases by the rod touching sea bottom, the sinker weights turn the suspending hook and the wire being released, the sinkers slide off as the rod is drawn upwards.

3006. Brooke's Rod, another mode of detaching sinker weights ; date 1857. Used in sounding North Atlantic.

3007. Skead's Weight Detaching Apparatus ; date 1857. By Mr. F. Skead, Master R.N., H.M.S. "Tartarus." Used in Mediterranean Sea survey.

A 68-lb. shot (represented by the wooden ball, exact size) is slung with wire, and the detaching apparatus attached. On reaching sea bottom, the small weight on the apparatus, which had till this time been kept above the hook by the weight of the shot, is freed, and, falling, reverses the hook; the shot is thus left behind. The small weight is roughed to secure a small portion of the sea bottom.

3008. Bonnici's Weight Detaching Clam ; date 1857. By Mr. C. Bonnici. Used in Mediterranean Sea survey.

A 68 lb. shot (represented by the wooden ball) is slung with wire, and the claw attached, the weight of the shot preventing the claw opening. On reaching sea bottom and the line slackened, the arms of the claw fall by their own weight, and the sinker is released.

3009. Bulldog Clam, for bringing up specimens of the sea bottom ; date 1860. Used in H.M. ships "Bulldog" and "Porcupine," North Atlantic Ocean.

The claw is kept open by a tubular sinker weight, resting on the four horns. When the weight is detached on reaching sea bottom, the india-rubber bands contract, closing the claw, and thus securing the sea bottom contained within it.

3010. Fitzgerald Sounding Machine, combining apparatus for detaching the weight and procuring specimens of the sea bottom ; date 1867. By Lieutenant Fitzgerald, R.N., employed in H.M.S. "Cordelia," in deep sea sounding between Jamaica and Cuba.

An iron sinker weight (represented by wood model) is hooked to the side of the sounding bar, and the hook or lever, to which the sounding line is attached, is inserted in the hole at the upper end of the bar. When suspended, the weight of the sinker keeps the lever in the hole and the bar nearly vertical. On reaching sea bottom, the scoop is driven into the ground, and the hook being freed by the slackening of the sounding line the weight falls over; the action of hauling in the sounding line reverses the bar, unhooks the weight, and the scoop closes with its contents.

3011. Hydra Weight Detaching Apparatus ; date 1868. By Gibbs, Artificer, H.M.S. "Hydra." Used in sounding Atlantic and Indian Oceans.

The wooden models represent (exact size) iron sinkers, each of one hundredweight; they are suspended on the sounding tube by the iron ring and wire, to a button which protrudes through a steel spring on the sliding rod above, the spring being kept back by the weight of the sinkers. On reaching sea bottom and the sounding line slackening, the rod slides down, the sinker weights then resting, the steel spring throws the suspending wire off, and the weights are left behind as the tube is drawn through them. A butterfly valve within the tube at the bottom secures a portion of the sea bottom.

3012. Baillie Weight Detaching Apparatus ; date 1872. By Navigating Lieut. C. W. Baillie, R.N. In general use in H.M.S. "Challenger."

Iron sinkers of half a hundredweight each (exhibited in wood models) in numbers sufficient for varying ocean depths, are placed on the sounding tube and suspended by the ring and wire to two shoulders that project from the sides of a sliding rod working in the upper part of the sounding tube. On touching sea bottom and the sounding line slackening, the sinker weights draw the sliding rod downwards, and the shoulders passing within the sounding tube, the wire is thrown off, and the weights released. The lower portion of the tube, to which a valve is attached, receives the specimen of the sea bottom.

3013. Burt's Bag and Nipper, for sounding in moderate depths without stopping the ship's way. Invented by Mr. Gould, an American (about 1812).

The bag is first soaked in water to render it air-tight, and when used is inflated; a wooden tube and peg is affixed for the purpose. The sounding line is placed in the nipper or snatch attached to the bag, and on the sounding lead being cast from the ship, the whole is thrown overboard, the inflated bag floating as the line runs through the attached nipper, the bag keeping immediately over the descending lead.

On the lead reaching the bottom, indicated by the spring of the bag, no more sounding line will pass through the nipper, and the place where it is thus nipped is the vertical depth of water as marked on the line.

3014. Massey's self-registering **Sounding Machine ;** date 1800. Adapted for moderate depths. In use in H.M. Navy.

3015. Ericsson's self-registering **Sounding Machine ;** date 1836. For sounding in moderate depths.

This instrument records the vertical depth irrespective of the amount of sounding line thrown out from the ship.

The depth is ascertained by the compression of air within a glass tube, the value of the compression, in accordance with depth, being recorded by the quantity of water passing into the tube as the air is compressed, and a scale adapted to it.

3016. Cup Lead. For sounding in depths not exceeding 1,000 fathoms, and to procure specimens of the sea bottom (about 1858); model. Originally used in sounding North Atlantic.

3017. Tube Lead. For sounding in depths not exceeding 1,000 fathoms, and procuring specimens of the sea bottom; date 1872; model. In use in H.M.S. "Challenger."

3018. Specimens of Sounding Line. Used in H.M. ships. No. 1. used in "Challenger"; No. 2. medium.

These lines are constructed of the best Italian hemp.

No. 1 line is one inch in circumference; 100 fathoms (or 600 feet) weighs 18 lbs. 9 oz. When wet this line breaks at a minimum strain of about 14 hundredweight.

No. 2 line is 0·8 inches in circumference; 100 fathoms weighs 12 lbs. 8 oz., and it bears a strain of about 10 hundredweight when wet.

THERMOMETERS AND APPARATUS FOR PROCURING SEA WATER, USED IN DEEP SEA EXPLORATION.

3019. Six's Thermometer, with protected bulb. Negretti. Designed by Fitz Roy and Glaisher (about 1860); used in H.M. ships "Bulldog" and "Porcupine" in North Atlantic.

3020. Six's Thermometer. Hydrographic Office pattern; bulb not protected. Casella; date 1867. Used in H.M. ships "Lightning" and "Porcupine" in North Atlantic.

This instrument (the full bulb of which was unprotected by an outer glass casing) was found to be affected by pressure, and gave erroneous results at great ocean depths; and this led to the construction of the protected bulb thermometer (3021).

3021. Six's Thermometer. Miller pattern; bulb protected as proposed by Dr. Miller. Casella; date 1869. In use in H.M.S. "Challenger:" generally adopted, after being tested to three tons on the square inch.

The full bulb is protected by an outer glass casing. The errors of these thermometers are determined under pressure, and are found to be reduced to the limits of about 1·2 for depths of 2,500 or 3,000 fathoms.

Two protected bulb thermometers which were broken by pressure at a depth of 3,875 fathoms in the Atlantic Ocean.

3022. Johnson's Metallic Self-registering Thermometer. Invented by Mr. Henry Johnson (about 1858). Not in general use.

3023. Saxton's Metallic Self-registering Thermometer (about 1855). Used on the United States Coast Survey. Not in general use.

3024. Water Bottle. In ordinary use for bringing up water from ocean depths. [Superseded in H.M.S. "Challenger" by Buchanan's design.]

3025. Water Bottle. Buchanan's; date 1872. A drawing. Invented by Mr. Buchanan, one of the scientific civilian staff attached to "Challenger."

3026. Barometer, Diagonal (about 1750). Watkins and Smith, London.

3026a. Barometer with Thermometer.
Paul Greiner, Hamburg.

The baro-thermometer, an instrument for measuring the depth of the sea, is also intended for recording the temperatures and the salinity of the sea water.

III.—SURVEYING AND OTHER INSTRUMENTS LENT BY VARIOUS CONTRIBUTORS.

3026b. Kater's Reversible Pendulum.
The Royal Society.

The original pendulum employed by Kater (Phil. Trans. for 1818), with the tail-pieces subsequently modified by Sir Edward Sabine (Phil. Trans. for 1829).

The pendulum is made to vibrate with one of the steel wedges called "knife-edges," resting on firmly-supported and carefully-levelled agate planes, and the vibrations are referred to a clock by the method of coincidences. The pendulum is then inverted so as to vibrate about the other knife-edge, and the movable weights are adjusted by a combination of calculation and trial, till the times of vibration about the two knife-edges are found to be the same. In this condition the length of a simple pendulum vibrating in the same time as the Kater is equal to the distance between the knife-edges, which can be accurately measured; and the length of the seconds pendulum will then be got by dividing by the square of the time of vibration expressed in seconds.

This pendulum has just been employed in a re-determination of the length of the seconds pendulum, particulars of which are nearly ready for publication.

3132. Pendulum Apparatus. Great Trigonometrical Survey of India. *Kew Committee of the Royal Society.*

The pendulum vibration apparatus used by Captain Basevi, R.E., and Captain Heaviside, R.E., in their pendulum operations in connexion with the Great Trigonometrical Survey of India, 1865 to 1874.

It consists of a vacuum chamber, of stout copper, firmly supported by a strong wooden stand; the chamber contains in its upper part a pair of agate plates, upon which the knife edge of the pendulum rests, and it has at the bottom an apparatus for starting and stopping the pendulum, as well as a graduated arc for determining its extent of motion. In the chamber there is also a fixed pendulum containing thermometers.

The Shelton clock exhibited with the other pendulum apparatus was used for timing the vibrations of one pendulum in the receiver, being firmly fixed to a wall erected for the purpose behind it.

The air pump served to exhaust the receiver, the vibrations being made in a vacuum.

The coincidences were observed by the small telescope erected at a distance.

3134. Pendulum Apparatus. Sabine.

Kew Committee of the Royal Society

Pendulum vibration apparatus used by Sir E. Sabine, and similar to that now in use by the Arctic Expedition under Captain Nares, R.N.

It consists of a massive iron triangular frame, supporting a pair of agate planes, upon which the invariable pendulum is swung; a strong wooden frame, carrying a Shelton clock, and a telescope, with which the coincidences of beat of the detached pendulum and that of the clock are observed.

3133. Photograph of a Reversion Pendulum Apparatus, distance of knife-edges 1 metre from each other, executed for the Central Bureau of the European Measurement of Degrees, Berlin. *A. Repsold and Sons, Hamburg.*

The apparatus consists of the *stand* made of brass tubing, the *pendulum*, the *scale*, and the *comparator*. The pendulum is a brass tube provided with knife edges. The scale is of the same tube as the pendulum, and contains a steel tube, and this again a zinc tube, both of which are united with each other and with the brass tube in such a manner that for the determination of the temperature a small divided scale which moves by the different expansion of steel and zinc, may be read off near one of the end divisions of the main (brass) tube. The divided surfaces are in the middle line of the tube. The scale may stand with either end upwards. By rotation of the comparator round its foot the two microscopes may be alternately directed upon the scale and upon the suspended pendulum.

3100. Photograph of a Base-measuring Apparatus, in course of construction for the United States Lake Survey, Detroit. *A. Repsold and Sons, Hamburg.*

A measuring rod 4 mètres in length is used, consisting of a steel and a zinc rod, enclosed together between rollers in a wide iron tube, and with divisions upon platinum at the ends. The measuring rod rests on its extremities (below the divisions) upon its supports, by which the advantage is attained that each support remains in place for two positions, and, therefore, only one has to be arranged for each new position. Before making a measurement microscopes are placed vertically upon separate supports above the rod-supports, and beneath these the rod is carried forward. To fix the daily termination a cylinder with a level is arranged perpendicularly under the last microscope on the small hemisphere of a terminal plate on the ground, and by the microscope a division on the upper terminal surface of the cylinder is read off in the two positions differing by 180°. The apparatus is accompanied by a comparator for the comparison—(1) of the measuring rod with a standard mètre; (2) of the measuring rod with a spare measuring rod. In the first case the standard mètre is laid, together with the measuring rods, upon a carriage 4 mètres in length, and compared one by one with the intervals of the measuring rod divided into mètres. For this purpose the carriage is moved to and fro upon the base piece under two microscopes placed upon a common bearer. This bearer may be pushed along the whole length upon the base piece (like the standard mètre upon the carriage). In the second case the two measuring rods are laid side by side upon the carriage, and compared under the microscopes, one of which is attached to the common bearer, and the other to a special arm of the base piece at a distance of 4 mètres from the former. The comparator is also arranged, if desired, for the comparison of the standard metre line measure (*à traits*) with a yard end measure (*à bout*). For this purpose small cylinders with scales are applied to the standard yard in order to compare suitable lines of these scales with the mètre; then the sum of the lengths of the cylinders up to the lines of the scale employed is found by putting the two directly opposite one another. The whole comparator is to be enclosed in a wooden case, in order to keep the measuring rods at an equable temperature.

3093. Experimenting Model (quarter of the natural size) for the preparation of bars for a new *base-measuring apparatus.*
Carl Bamberg, Berlin.

The steel tube is bored through cylindrically in an axial direction, closed at the ends and filled with mercury, which also passes into a glass tube, closed above, and communicating with the bore. The height of the column of mercury in the glass tube will be a measure of the alteration of the length of the scale by change of temperature. The proportions of the cavity of the passage in the steel and glass tubes are so arranged that every change of length in the scale is increased 100 times in the glass tube.

This instrument has been made as an experiment by order of the Royal Prussian Land Survey.

3093a. Drawing of a Base-measuring Apparatus, with employment of the measuring bars mentioned with the above apparatus. *Carl Bamberg, Berlin.*

1831a. Telescope, by Dollond.

Sextant by Ramsden. *Prof. Winnecke, Strasburg.*

Universal Instrument and Goniometer, by Robinson.
Prof. Winnecke, Strasburg.

The telescope is the "Dollond," so often mentioned in Humboldt's account of his travels in America.

The sextant and the universal instruments was taken by Humboldt in all his journeys in Asia and America, and on the former depend nearly all the determinations of position. It contains an inscription to this effect, and in the case may still be found the paper in Humboldt's handwriting with instructions for the engraver.

These instruments form a portion of the Humboldt collection, with which friends in Berlin enriched the new observatory of Strasburg, erected in the year 1873.

3106a. Quadrant used by Captain Cook during his several voyages. *Richard Caulfield.*

3027. Instruments used by the late **Dr. Livingstone** in his *last* journey. *The Royal Geographical Society of London.*

Pocket chronometer, by Jas. McCabe, 194, Royal Exchange, London.
Sextant, by John Dalton, of Hartlepool.
Hypsometrical boiling apparatus, by Casella.
2 boiling point thermometers, by Casella.
1 ordinary thermometer, by Casella.

3153e. Two Cases of Instruments used by the late Captain Speke in Africa, with map of his discovery of the region of the Nile sources. *William Speke, jun.*

3027a. The First Traces ever found of the Franklin Expedition. *Admiral Ommanney.*

a. THEODOLITES.

3039. Five-Inch Theodolite by Adams. *Royal Society.*

3047. Theodolite with 3-inch circle.
Messrs. Troughton & Simms.

The telescope is of the bent form, having a small rectangular prism in the axis. The light received by this prism is turned through the axis of the instrument, and an image of the object is formed outside the pivot. By this construction the instrument may be kept low, and possess at the same time considerable optical power.

3047a. Five-Inch Theodolite. *Joseph Casartelli.*

In making this theodolite the object has been to reduce the number of parts and simplify the construction. It has double conical bearings to the axes, with a ball-and-socket adjustment, and spring verniers to the horizontal circle, producing an easy and smooth motion. The whole is made of gunmetal.

3047b. Travellers' Transit Theodolite and Stand. Improved by the late Lieut.-Col. Strange, F.R.S., and adapted for alpine and military surveys or occasional astronomical observations. *L. Casella.*

3047c. Travellers' Transit Theodolite and Stand, with telescope in centre. Improved by the late Lieut.-Col. Strange, F.R.S., and adapted for alpine and military surveys or occasional astronomical observations. *L. Casella.*

3047d. Cary's Improved 5-in. Theodolite, with improved rack adjustment to cross webs of eyepiece, and improved form of tripod foot. *Henry Porter.*

3048. Theodolite (10·5 in.), in which the vertical arc is jointed on an ordinary sector, and covered with a variety of scales. Made by Sissons, London. *Major M. L. Taylor, R.A.*

3049. Repeating Theodolite, horizontal circle 14 cm. in diameter, divided to 20′ reading to 30″ by vernier. The divided limb is completely covered and the verniers are protected by glass plates. Telescope, 12 lines free aperture, magnifying 25 times, vertical circle divided to 30′ reading to 1′ by vernier. Level to arrange the telescope in two positions. *A. and R. Hahn, Cassel.*

Besides the addition of the movable level to the telescope, this instrument possesses a new arrangement for its vertical movement. A small female screw with right and left threads on opposite sides is inserted near the base of the bearer. Corresponding to these threads are male screws tightly fastened to the bearer, and, by turning the female screw to the inner or outer side, the height of the telescope is increased or diminished.

3050. Universal Theodolite (Bende's construction), horizontal circle 12 m. diameter, divided to 20′ and reading by two verniers to 30″. The divided limb is completely covered, and the verniers are protected by glass plates. Telescope, 15 lines aperture, magnifying 35 times, adapted for reversal in the bearings, level for setting; tangent screw exactly 1 mm. range. The vertical arc is replaced by a long tangent screw with micrometer head, by which vertical angles up to 45° can be measured.

A. and R. Hahn, Cassel.

By means of this instrument elevations can be measured directly with the tangent instead of by the arc or its chord as hitherto. Its advantage over other instruments consists in its peculiar construction, which admits of using the micrometer screw in the measurement of angles up to 45°, whilst hitherto angles up to about 10° only have been so measured. The relation between the reading on the screw and the height or distance to be measured is a simple geometrical one.

3051. Repeating Theodolite (No. 148), with stand and leather case. *Otto Fennel, Cassel.*

Covered horizontal circle, 14 cm. in diameter, graduated on silver to 20′, and reading by vernier to 20 seconds. Achromatic erecting telescope. Vertical circle with vernier reading to minutes.

3052. Metford's Improved Theodolite, made by F. Pastorelli, under the direction of the inventor. *Francis Pastorelli.*

DESCRIPTION OF THE INSTRUMENT.

Levelling Gear.—It consists of three left-handed screws with the balls fitting closely to their beds on the under surface of the traversing box; they are secured by an elastic three-cornered plate, having boxes at their ends to protect them from dust and grit. The lower ends of the three screws pass through a triangular plate with broad ends, with sufficient spring to permit the female screws to be slightly twisted.

Traversing Stage.—The main hollow centre of the instrument carries a circular disc $3\frac{1}{2}$ inches in diameter and $\frac{2}{10}$ of an inch thick; the traversing stage is a flat plate $5\frac{1}{2}$ inches in diameter; in its bottom the levelling screws are seated as previously explained. The upper surface has a ring round its edge the depth of the circular disc. There is a 2-inch hole in the stage to let the plumb cord traverse with the instrument; the disc will traverse 1 inch in any direction from the centre. To secure the instrument there is an upper plate screwed to the ring, so that the stage becomes a very shallow box; there is also a washer that keeps out dust and grit. A three-arm pinching screw running on the hollow centre secures the disc.

Horizontal Limb and Vernier Plate.—The horizontal limb and vernier plate are solid; the latter has mounted upon it a compass, circular bubble, and a memorandum plate; also attached to it is the tangent motion. The limb i divided to read 20 minutes, the vernier to 30 seconds.

Bracket Support of Vertical Limb and Telescope.—On the side of the main pivot is attached a strong curved bracket with two arms at the top. This bracket has a T section throughout; to it is fixed the vertical circle and female centre. The telescope and vernier circle, with its tangent motions, are fixed on the male centre. The main spirit bubble is fixed at the back of the vertical circle; there is a screw in the bracket for perfecting its adjustment. The axis of the telescope is suspended over the axis of the instrument, and admits of a transit motion; this is an important improvement.

Tripod Staff Head.—This is an adoption of W. Froude, Esq., C.E., F.R.S., by which steadiness is obtained, which is of great importance in taking angular measurements. The cheeks are set wider apart, the leg joints being similar to an inverted mortar with strong trunnions, which can be tightened in their bisected cylindrical bearings by means of capstan-headed screws. As wear goes on they can always be kept perfect; this cannot be done with the ordinary staff head.

3052a. Metford's 7-inch Theodolite, with curved arm instead of the usual structure for carrying the vertical circle, and telescope, mounted on his traversing stage, with legs, invented by Mr. Froude. *H. Husbands.*

3052b. Metford's 4-inch Theodolite. Instead of being mounted on the traverser is placed on the ball movement, and is more especially recommended for very steep and hilly ground, and for preliminary surveys. *H. Husbands.*

3052c. Theodolite. An extremely old, if not unique, instrument, purchased by the late Sir James South as a rarity. In the original oak box. *G. J. Symons*

3053. Small Theodolite, for rapid operations.
Geneva Association for the Construction of Scientific Instruments.

This instrument presents the following advantages:—

The telescope is reversible to give the correction of the zero of the vertical circle.

The position of the level is symmetrical.

The divisions are strongly marked for rapid observations.

The vertical circle has two graduations; one to show degrees and minutes, the other tangents. This latter division shows the reduction for inclination without computation.

3054. Gambey's Theodolite.
Conservatoire des Arts et Métiers.

3059. Large repeating Theodolite, with arc and altitude circle, divided to 10′; with verniers for direct reading to 10′.
Dennert and Pape, Altona.

3060. Theodolite with circles of six and four inches.
Julius Wanschaff, Berlin.

This theodolite has been constructed (of greater durability than usual) for making very accurate measurements. The division is not the exhibitor's;

only those on the reflecting circle, and on the universal instrument, were made with the exhibitor's new machinery.

The circles on both these instruments have no errors which could be detrimental, or which can be ascertained by the instruments themselves, since the exhibitor's dividing machine (of 90 cm. diameter) is only arranged for copying, and the normal-division itself being correct as far as 1·2 seconds.

The horizontal circle on the theodolite can be turned, and is provided with a contrivance for centering; the verniers indicate at a division of—10 to 10 minutes—10 seconds. Those on the altitude circle indicate at a division of —20 to 20 minutes—30 seconds.

3062. Universal Instrument with eight-inch Circles, and reading microscope. *Julius Wanschaff, Berlin.*

The circles on the universal instrument read to four seconds, but they have only figures of half the value, in order to obtain at once the mean by the addition of the two readings of the opposite microscopes.

3066. Small Universal Instrument for measuring heights, &c., with stand. *Zimmer Brothers, Stuttgart.*

Small levelling instrument and theodolite in one, for measuring heights, horizontal angles, &c., and for levelling, and setting out right angles. Useful to foresters and agriculturists, on account of its cheapness, and capability of being easily handled.

3073. Theodolite with two Vertical Circles.
Geodetic Institute of the Royal Polytechnic School, Munich, Prof. Dr. von Bauernfeind.

This instrument was made by Ertel & Son, of Munich, from the exhibitor's design, and is suited for investigations as to the relative value of the vernier and microscope readings of five divisions, and, secondly, for observations upon the magnitude of terrestrial refractions and their variation with temperature and the pressure of the air. The exhibitor has not yet described the instrument, because the number of observations made with it is still too small to allow certain results to be deduced from them. The instrument, however, perfectly fulfils its purpose.

3074. Repeating Theodolite, with 15 cm. horizontal circle, and 12 cm. covered altitude circle. *A. Bonsack, Berlin.*

Both circles are divided on silver; the first to 20′ with two verniers reading to half minutes; the second to 30′ reading to one minute by one vernier. The telescope is adapted for distance measurements by a method invented by the exhibitor, and which has been strongly recommended by Herr S. Woyike, who used it in operations on the Ostbahn.

3075. Theodolite with Micrometers on the horizontal circle. *F. W. Breithaupt and Son, Cassel.*

Theodolite for Geodetic purposes.—Horizontal circle 20 centimètres in diameter, with two graduations. the coarse to 20′, the fine to 5′, reading by micrometers, to two seconds directly; the fine division is protected by a cover; the verniers of the vertical circle show 10 seconds; orthoscopic telescope for transit (*Durchschlagen*) and *reversal* in the Y's with arrangement for distance-measurement, reversing spirit-level and level on the tube of the telescope. The microscopes have parallels and reversion scales on glass. This theodolite belongs to the Royal Forest Academy at Münden.

3076. Pocket Theodolite.

F. W. Breithaupt and Son, Cassel.

Capable of employment, on account of its small dimensions, in very confined spaces, mines, &c.

3077. Francis' Patent Pocket Theodolite, made by Negretti and Zambra.

George Francis, C.E.

The improvements claimed for this invention are, 1st, its portability and cheapness; 2nd, its simpleness and easy application; 3rd, the proportional increase of length between the sights for dialling; 4th, it is less liable to error in taking horizontal angles; 5th, its adaptability for taking the angle of an underlie or gradient; 6th, it requires little or no adjusting; it combines with the theodolite a clinometer, protractor, and plotting scales for reference, from 1 to 60 feet to the inch.

At *each* setting of the instrument, the following observations can be taken: —1st, the horizontal angle of the back and forward sights to $\frac{1}{60}$th part of a degree; 2nd, the magnetic bearing to $\frac{1}{4}^{\circ}$; and 3rdly, the rise or fall in the sight to 1′ and also in inches to the fathom for perpendicular and base.

3080. Repeating Theodolite, with reading microscopes.

Dennert and C. W. Pape, Altona.

The tripod stands on screws which turn upon separate supports. The instrument is fixed to the stand by a brass plate pressed up against the lower surface of the head by a screw and spiral spring. The body rests upon an annular horizontal surface and can be turned accurately round its axis, an arrangment which enables the repetition movement to be accurately made. The vertical axis of hardened steel and the horizontal circle are firmly united with the body and round the vertical axis turns the upper part, having two double arms and serving as a support for the bearers of the axis of rotation of the telescope, which is arranged for reversal and carries the vertical circle, with an arrangement for vertical repetition. On the other end of the axis is the counterpoise with a graduated circle. The telescope has an achromatic object glass and orthoscopic eyepiece upon which a prism and sun glass can be placed. The cross wires consist of spiders' threads and are held by adjusting screws. Provision is made for illuminating the cross threads for observations at night. The two circles are divided into sixths of degrees, and by means of two micrometers accurate readings to 10 seconds may be obtained.

3081. Theodolite for Horizontal Angles with reading microscopes.

Imperial German Navy (August Lingke and Co.).

3082. Theodolite, with reading microscopes.

Ed. Sprenger, Berlin.

Theodolite, with horizontal and vertical circles 0·17 meter in diameter.—Both circles reading by microscopes to 2 seconds. Focal length of telescope, 0·32 m.; magnifying power, 36 times. The tripod has a complete circle, and a third microscope for the exact and easy examination and determination of the errors of division. The substructure and axis bearer are of a single piece of cast steel, coated with chloride of platinum for protection from rust. The circles are solid and coned, by which means unequal expansion is avoided; this is not the case with spoked circles. The object-glasses are by Fraunhofer's successors at Munich.

The Topographical Department of the Royal Land Survey has exhibited a telescope ruler, which is now introduced by the Department. It has double verniers and a reversing telescope, and is also furnished with a double bubble-tube, rendering the instrument very useful for levelling. The distance-measure is removable, but so contrived that no screw is visible outside, so that nothing can act upon it.

3082b. 6-inch Transit Theodolite. *G. W. Strawson.*

3082c. 5-inch Transit Theodolites (2). *G. W. Strawson.*

3106. Repeating Theodolite. *Meissner, Berlin (H. Müller and F. Reinecke).*

3072. Distance and Altitude Measuring Theodolite, by Dennert and Pape, Altona, with stand. *Prof. Helmert, Aix-la-Chapelle.*

The theodolite is intended for topographical surveys. The division of the circles is so fine that frequently the reading of one index will suffice, its position being appreciable to 1 minute with the lens, without the employment of the vernier. As the stand has great stability, the vernier arm is not movable together with a spirit level, but both are fixed.

3079. Tachymeter (theodolite), with stands. *Bau Deputation, Hamburg.*

3079a. Theodolite (Tachymeter), from the mechanical workshops of Dennert and Pape, Altona. *Royal Prussian Ordnance Survey Department.*

This was specially constructed by Dennert and Pape, Altona, according to the directions of the Survey Department for the measurement of distances and heights, as well as for geodetical purposes. The arrangement has been such that, besides lightness, sufficient stability is afforded for work of such a nature. The circles are divided to 10′, so that they can be read without the aid of the vernier to 5′, and that the operator is not obliged to leave his place during the work for the purpose of reading at the circles.

For distance and height measurement, after the centre horizontal thread has been adjusted to any point of the levelling staff, and the readings taken, and the difference of the readings for the two threads, as well as the reading of the centre thread, is noted in the field book.

For the observation of the line of direction of other stations, the circles are fixed by the clamping screws, and the exact adjustment obtained by means of the micrometer screws.

3089a. Topographical Instrument, called **"Cleps,"** constructed by Messrs. Salmorraghi, Rizzi, and Co., Milan. *M. Antoine d'Abbadie, Member of the Institute,* 120, *Rue du Bac, Paris.*

This altazimuth has three peculiarities :—

1st. The telescope is very powerful for its size.

2nd. Through the small transverse eyepiece the observer may read at the same time the horizontal and the vertical angle; the divided circles, completely covered, being lighted from above. To save time, there is neither microscope nor vernier, the angles being estimated in 10ths of divisions by three apparent wires, the means of these three estimations only being used.

3rd. The division is decimal; each hundredth of the quadrant is numbered, and divided into five parts.

The error of collimation is ascertained by reversing the ring that supports the wires. This instrument, constructed for topography, is of small dimensions. In the larger model the division is carried to the thousandth of the quadrant.

3089b. Aba, or new **Altazimuth.** Designed by the exhibitor.
Antoine d'Abbadie, Membre de l'Institute.

The sextant, so useful at sea, is not a traveller's instrument, for it requires on land an artificial horizon, and cannot give, without much trouble, the small angular heights and true bearings of distant terrestrial objects, so useful in mapping. With common altazimuths time is lost in adjusting the levels and collimation error. These two adjustments are avoided in the "aba;" by construction the errors are brought down to narrow limits, are determined by reversals, and remain practically constant. The telescope is very powerful for the size of the instrument in order to ensure easy vision. The observer can read his verniers without shifting his position. There is no inferior or fiducial telescope, as the observer, after going round his horizon, takes care to repeat his first bearing, so as to provide against any motion in azimuth. A pinion and tooth-rack supply the place of clamp and screw, thus saving time and trouble.

The verniers read to the ten thousandth part of the quadrant or right angle (equal to 32″·4), this decimal division being preferred, on trial, by persons already accustomed to sexagesimal divisions. It is likewise more easily learnt by beginners. The figures indicate hundredths of the quadrant, and are marked so as to be very easily read. From the jutting position of the object glass it is possible to take the bearing of a signal at the very foot of a tower or wall. As screws get loose in travelling, the maker has employed fewer of them than it is usual in altazimuths. A powerful screw is attached to the stand and fastens the box on its top, before sliding off its superior part, which can thus be quickly put on again in case of a sudden shower of rain. The small box is destined to contain a thermometer for calculating atmospheric refraction, sun glasses, &c.

By taking corresponding azimuths of the sun on the same day or on two ensuing ones, the latitude is obtained together with true bearings of all visible objects, while the compass gives the needle's variation.

A person familiar with the use of the sextant only, on observing circum-meridian altitudes for his first attempt with the "aba," obtained his latitude to within 4″.

3101. Geodetical Tachygraph, a representation of an instrument invented and constructed by the exhibitor, for conducting measuring operations in their minutest details.
Prof. Joseph Schlesinger, Vienna.

This instrument consists of a circle with divisions, mounted in a movable frame, that can be adjusted so as to place the circle in any given direction. It is also provided with a rule to plot angles.

3102. Eckhold's Omnimeter, for measuring linear distances by one and the same operation. *Elliott Brothers.*

This instrument is a transit theodolite, with an apparatus for measuring by one operation the distance of an object or staff of a determined length, and its height over or under the level line of the instrument; the former with the accuracy of a good chaining, the latter with the precision of a perfect levelling, and accomplishes the work of theodolite, level, and chain with a great economy of time.

3109. Tacheometer of Gentilli, a telescopic instrument for measuring heights and distances, in surveying difficult country. Without calculations it measures accurately distances up to 400 meters, or over 1,300 feet, with an error of less than $\frac{1}{2000}$. *Dr. Karl von Scherzer.*

This instrument was invented by M. Amadeo Gentilli, an eminent Austrian engineer at Vienna. Its use is for the measurement of heights and distances in the survey of difficult ground, and it has proved especially useful in surveying the contour-lines of mountainous districts. The means by which it measures the distance is an apparatus which obliges the telescope to traverse a precise and unvarying angle. The test of value of this instrument is the fact that, with a magnifying power of 40, it measures distances up to 400 meters with such exactness that the maximum error is less than $\frac{1}{2000}$ of the distance.

The horizontal axis of the instrument revolves in the head of a vertical arm, which can be clamped to it when the measurement of a distance is to be made. The motion of the lower end of this arm is effected by a slow-motion screw, and limited in each direction by an adjustable stop.

3109a. Laslett's Metroscope. For measuring inaccessible heights and distances, and for levelling. *Thomas N. Laslett.*

For the use of architects, engineers, and the military. Heights are read off as decimal parts of the horizontal distance. Distances are measured by readings from the two ends of a base line, which base line may be vertical, or lie in the direction of the object, or at right angles to that direction.

Lineal dimensions only are used; no degrees angles, or tables. With the index at zero the instrument becomes simply a spirit level.

3109b. Drawing of Metroscope. For the determination of dimensions of distant objects.

Dr. Snellen, Physiological Laboratory and Ophthalmological School, Utrecht.

Before the objective of a telescope are placed two mirrors, one above the other, each occupying one half of the field of view, and inclined to the plane of the objective at an angle of 45°, the angle between them being 90°. On a cross bar, at each side, a mirror parallel to the first is movable. Looking through the telescope, by means of these two sets of mirrors, two objects, seen straight above each other, must be, at whatever distance they are from the observer, at a mutual distance equal to the distance of the two outer mirrors. (Handbuch der Ophthalmologie, von Graefe und Saemisch, III. p. 203.)

3124. Universal Instrument, by Breithaupt and Son, Cassel. *Royal High School of Industry, Cassel (W. Narten).*

Universal Instrument, with distance-measurer for levelling and measuring horizontal and vertical angles.—This instrument is intended for large surveys and levellings, which require to be performed with great accuracy and as little expenditure of time as possible. It corresponds with the tacheometer, but exceeds this in the amount of work that can be got through with it. The telescope rests with prisms and screw-heads upon the steel plates of a bearer, and, like the spirit-level, may be reversed; the bearer, furnished with a double altitude arc, lies with its axis in closed rests, and has a vertical movement and a fine adjustment by means of micrometer screws; a spirit-level on the head of the axis serves for its accurate adjustment in a perpendicular position. Horizontal circle, with glass coverings to the verniers. Constructed in 1854 by F. W. Breithaupt and Son.

4561. Photograph of the Universal Instrument of Luigi Pelli, for levelling operations, trigonometrical and graphic, by being adapted to the Prætorius table. *Luigi Pelli, Florence.*

The universal instrument of Luigi Pelli serves for levelling operations, being mounted like the most exact telescope-levels. It serves for the same trigonometrical operations as the theodolite, having an azimuth circle similar to that of the repeating theodolite, but with only two verniers. The alidade is placed so as to coincide with the plane of the tablet by means of a central screw situated in the column which sustains the telescope. A point fastened with springs within the screw marks on the paper the centre of the azimuthal circle. In this manner angles may either be measured or plotted at once.

3130. Photograph of an Altitude Circle, objective of 2·1″ aperture, diameter of circle 10½″. Latest construction of the instruments of a similar kind extensively in use in Russia for determining geographical positions.

A. Repsold and Sons, Hamburg.

b. Reflecting Circles.

3061. Ten-inch reflecting Prismatic Circle, similar to that of Pistor-Martin. *Julius Wanschaff, Berlin.*

3087. Reflecting Prism Circle, 10 in. diameter.
Meissner, Berlin (H. Müller and F. Reinecke).

3088. Reflecting Prism Circle, 6 in. diameter.
Meissner, Berlin (H. Müller and F. Reinecke).

The reflecting prism-circles can be recommended on account of their excellent execution, in optical as well as in mechanical respects, and also on account of their cheapness.

3115. Reflecting Circle, according to Pistor and Martins.
F. W. Breithaupt and Son, Cassel.

3115a. Improved Reflecting Circle of Pister and Martins. *The Pulkowa Observatory.*

A full description of the patent reflecting circle of Pister and Martins in its original construction is given by the inventors in the Astronomische Nachrichter, vol. xxiii. In the form exhibited general improvements are introduced by the inventors on Professor Dallen's suggestion; for instance, all correction screws of the prism are removed, the stiffness of the main body is considerably increased, the different parts of the instrument are more symmetrically disposed, the telescope and the dark glasses are separated from the radius, on which mirror and prism are fixed, means are given for cross observation to the extent of 288°, &c. Also, the stand for observations on shore is in parts changed and endered more practical.

2993a. Allen's Reflecting Circle, for repeating the observations and reading the angle on any portions of the circle, so as to eliminate errors of graduation or workmanship.
W. Watson and Son.

1722b. Double Reflecting Circle, by Capt. Owen, R.E. The property of the Royal Astronomical Society.
Robert J. Lecky, F.R.A.S.

This invention of the late Capt. Owen, R.E., is peculiarly valuable for the readiness with which two observations or "sights" can be taken with it, without removing the instrument from the eye, *e.g.*, in a lunar observation at sea the altitude of the star and the lunar distance may be taken with great rapidity, as well as in other observations.

The two circles each six inches diameter are divided on silver and read by three verniers on each to 20 seconds of arc, and the glasses being placed between the circles are well defended from accident at sea. It has other adaptations of much ingenuity.

3038a. Repeating Circle, of 1 foot diameter, by Troughton.
Royal Society.

3111. Portable Repeating Circle (14 centimetres).
J. & A. Molteni, Paris.

3088a. Prismatic Compass (german silver).
G. W. Strawson.

3088b. 3½-inch Prismatic Compass (bronze).
G. W. Strawson.

3088c. Singer's Gilt Compass. *G. W. Strawson.*

c. LEVELS.

3037. Large Levelling Instrument by Cary.
Royal Society.

3038. Large Levelling Instrument by Troughton and Simms. *Royal Society.*

3063. Levelling Instrument with telescope of 15″ focal distance, 1·6″ aperture; a so-called compensation plane with rotating level. *Ott and Coradi, Kempten, Baviera.*

This "compensation level" is a levelling instrument with telescope, which can be turned round its optical axis and reversed in its sockets. The water level is firmly fixed to the telescope, and can be turned in sockets round its own axis in such a manner that on rotating the telescope through 180° the scale of the water-level can be always turned upwards.

The object of this arrangement is to eliminate the errors occurring by damage of the telescope rings, and to give to the engineer at all times the possibility of correcting the instrument as easily from any position as in a levelling instrument with reversible telescope, with exactly equal ring diameters and adjustable water-level. By this arrangement the tedious reversing of the telescope and the adjusting of the water-level, which easily give rise to injury, will be rendered superfluous. Other constructors have endeavoured to obtain this result by the employment of double-cut water-levels; a correct construction, however, of such instruments is very difficult, and any errors incurred cannot be corrected.

3046. Patent Level. A combination of the Y and Dumpy patterns. *Patrick Adie.*

3045. Theodolite-Level. A combination of the two instruments. *Patrick Adie.*

3046a. Dumpy Level, of improved construction. *Joseph Casartelli.*

With graduated circle, for taking horizontal angles, and ball-and socket motion greatly facilitating its adjustment, especially on hilly or uneven ground, and saving the wear of the adjusting screws. The instrument being made of hard gun-metal, and the centre being long and accurately ground, renders it little liable to derangement.

3086. Levelling Instrument. *Meissner, Berlin* (*H. Müller and F. Reinecke*).

This levelling instrument is distinguished by its simple and unchangeable arrangements for correction.

3089. New Levelling Instrument, constructed by A. Geppert, completed by F. Miller. *F. Miller, Innsbruck.*

This instrument is adapted especially for surveyors and engineers in mountainous countries. The arrangement is as follows:—The vertical axis is placed perpendicularly by means of 4 screws. It is provided with a horizontal graduated circle reading by means of a vernier, to two minutes. The astronomical telescope magnifies 15 times, and is capable of 14 degrees of depression or elevation. The inclination of the telescope is measured by a micrometer screw. Its uses are: Direct and indirect levelling, measurement of height and distance, horizontal angles, &c., and plotting the same.

3104. Abney's Level. The instrument was designed by Capt. Abney, R.E., F.R.S., for military reconnaissances. It measures vertical angles by means of a spirit level attached to a graduated arc, which is capable of moving round an axis. The object whose angle of depression or elevation is to be ascertained, is brought into the field of view, and the spirit level is then moved till the bubble is in the centre. When in this position the bubble is seen in a reflector placed in the body of the tube; an opening being left for the purpose. *Elliott Brothers.*

3105. Elliott's 14-inch improved **Dumpy Level,** with compass for taking levels and bearings. *Elliott Brothers.*

This instrument, being provided with an object glass of large aperture and short focal length, and sufficient light being thus obtained to admit of a higher magnifying power in the eyepiece, the advantages of a much larger instrument are obtained. A mirror is placed over the bubble, so that the operator can see, while reading the levelling staff, if the instrument keeps its proper position; this being necessary on soft and spongy ground.

3105a. 14-in. Dumpy Level, with improved rack adjustment to cross webs. *Henry Porter.*

3105b. Twelve-inch Gun Metal Engineer's Level, with channelled bottom, for setting flat work, shafting, &c. Very delicate. *Joseph Casartelli.*

3105c. Small Improved Builder's Level, working parts all made of gun-metal. *Joseph Casartelli.*

3105d. Ten-inch Dumpy Level, with long centre improved construction, and the working parts all made of gun-metal. *Joseph Casartelli.*

3105e. 12-inch Level. *G. W. Strawson.*

3105f. 10-inch Level. *G. W. Strawson.*

3110. Level, with independent bubble, Gravet's system, with stand. *M. Tavernier Gravet, Paris.*

3112. Patent Surveying Level. *Francis Pastorelli.*

This instrument combines several important improvements, including increased facility in use, greater steadiness and freedom from vibration and possibility of derangement, accurate adjustments, and great durability.

Tripod and Staff Head.—Stability is of the utmost importance. This is secured in the staff head (which is the adoption of a plan by Wm. Froude, C.E., F.R.S.), which has the cheeks set wider apart, the leg joints being similar to an inverted mortar with strong trunnions, which can be tightened in their bisected cylindrical bearings by means of capstan headed screws. As wear goes on they can always be kept perfect; this cannot be done with the ordinary staff head.

Ball Joint and Clamp.—The instrument is free to move with 20° of inclination. This is most important, as much valuable time is saved, more especially upon hilly ground, as it can be almost set instantaneously.

Adjustments.—The parallel screws work in movable hemispherical nuts, which are held in seats in the parallel plates, those in the lower being held in brackets. Their action permits the upper plate to be worked at an inclination of about 15° without their being strained or twisted. By their means the upper parallel plate is made to clamp or set free the inverted cup on the vertical axis of the instrument; in addition, they cause it to heel over to perfect the adjustment, so as to bring the main bubble in the centre of its run whenever a force is applied to them greater than is necessary to clamp the inverted cup.

Suspension of Telescope.—The telescope is solidly fixed to its base, which is parallel to the axis of it; it has a female screw with a true surface which fits on to the gun metal centre, so that when the instrument is reversed in any direction the main and circular bubble is retained in the centre of their run. Around the telescope are two gun-metal collars, accurately turned and ground to a perfect circumference; by their means are adjusted the mechanical and optical axis of the telescope and the line of collimation; the main bubble is dead fitted; it neither admits nor requires adjustment, as it is done in construction.

Diaphragm.—The diaphragm with its collimating screws cannot be disturbed. A grooved channel is formed in the eye end of the telescope, into which they are sunk, and a cylindrical ring conceals them from sight, thus keeping them intact. This is one of the important adjustments of the instrument.

3112a. 12-inch Level mounted on the Ball movement.
H. Husbands.

The 12-inch level is mounted on the ball arrangement, the combined invention of Mr. Metford and Mr. Froude.

3113. Levelling Instrument with Telescope, 40 cm. long, arranged for rotation and reversal in its sockets, with stand.
A. Bonsack, Berlin.

The bearers are closed by springs. The horizontal circle is divided on silver to ½°, and adapted for reading to one minute.

3114. Compensation Level.
F. W. Breithaupt and Son, Cassel.

A portable instrument. It possesses the important advantage that, without previous correction, even if the telescope-cylinders are unequal, correct levels may be obtained, provided that the spirit-level is correctly adjusted, which may be easily ascertained by turning it round in its points of suspension. By means of the tangent screw the spirit-level is brought to equilibrium in both positions of the telescope, and the mean of the two readings is taken. By this operation all errors are compensated. The divided head of the tangent screw serves at the same time for distance-measurement; and, besides, a distance measure on glass is inserted in the eyepiece of the telescope for direct measurement.

3116. Levelling Instrument of Precision, with telescope of 15″ focal distance, 1·6″ aperture, a so-called **Compensation Level** with rotating water-level, according to new patent construction. *Ott and Coradi, Kempten, Baviera.*

3117. Levelling Instrument with horizontal circle.
Imperial German Navy (August Lingke and Co.).

3122. Large Reversible Level, for precision levelling. Length of the telescope 0·50 m., magnifying power 36, 65 diameters, in steel sockets, with reversing level of exactly equal tangents, indicating five seconds, latest construction. *Ed. Sprenger, Berlin.*

Length of telescope 0·44 meter, magnifying power 40 times, with a new construction of double spirit-level in one individual of exactly equal tangents, by which the employment of the second position of the telescope is greatly facilitated, and the instrument works with great precision, as any inequality in the bearing rings of the telescope immediately becomes visible. The support with the bearers is of cast steel in one piece, and to protect it from rust is coated with chloride of platinum. From this construction the instrument has great stability. The object glass, eyepiece, and field glass are removable, so that the telescope is free from optical errors. The bearing rings of the telescope are of aluminium-bronze, and there are removable distance-threads.

3123. Large Reversible Level, for precision levelling. The telescope 0·36 m. in length, magnifying power 28 times, in all other respects like the previous one. *Ed. Sprenger, Berlin.*

3125. Levelling Instrument, with rotating and reversing telescope, by Breithaupt and Son, Cassel.
Royal High School of Industry, Cassel (W. Narten).

The telescope and the spirit-level, as in No. 3124 arranged upon prisms, screws, and steel plates for reversal and distance-measuring. This arrangement, fulfilling the same purpose as the cylinder on the telescope, has the further advantage that any wearing that may be produced by the screws may be at once corrected without the aid of the mechanician. The instrument is particularly adapted for levellings of precision ; that now exhibited was employed in this way in the European measurement of a degree by Prof. Spangenberg.

d. Quadrants and Sextants.

3083. Quadrant, of boxwood. One side engraved as usual, on the other are numerous figures and a movable index.
William Sykes Ward.

3084. Gunter's Quadrant, of boxwood.
William Sykes Ward.

3085. Quadrant, of brass ; one side divided as a geometrical square, the other with movable circle and index, signs of the zodiac, and various figures. *William Sykes Ward.*

3067. Sextant of Aluminium, constructed by A. Petri, Rostock. *Prof. H. Karsten, Rostock.*

3085a. Jacob's Staff, made to take astronomical observations, with double arcs ; 17th century.
Ministry of Marine, Madrid.

3085b. Surveying Instruments of the 18th Century.
Ministry of Marine, Madrid.

3085c. Two Double Sextants, made in the last century by Davis. *Ministry of Marine, Madrid.*

3031. Double Pocket Sextant, an instrument for travellers. Made by H. Porter. *Capt. C. George, R.N.*

It can be used on shore with artificial horizon, in obtaining altitudes near the zenith ; also as two single sextants, one of which can be used in case of the other being damaged ; or one can be used by an assistant, and the other retained by the observer.

It can measure angles of nearly double the arc which can be measured by the ordinary sextant.

It can be used for the simultaneous measurement of two angles in the same place.

For laying out curves for railways and harbours, it is invaluable to the civil engineer and marine surveyor.

3033. Large Double Sextant (6 in. radius) for taking two lunars simultaneously; an instrument for travellers. Made by H. Porter. *Capt. C. George, R.N.*

3033a. Capt. George's Improved Double box Sextant. Made by H. Porter. *Capt. C. George, R.N.*

This instrument enables the observer to take right and left angles simultaneously, thus combining rapidity of use with great portability.

3033b. Box Sextant with improvement of wheel head to telescope, and case. Made by H. Porter. *Capt. C. George, R.N.*

3107a. Improved Box or Pocket Sextant. To enable the observer, when sounding from a moving boat or vessel, to take both angles in fixing a position, without delaying to read off one angle before taking the other. *Capt. J. E. Davis, R.N.*

This is effected by means of a supplementary arc and vernier, not affected by moving the proper arm unless connected by means of the hook and pin.

When used, the arms are connected, and the larger angle is taken first, the hook is then pushed back, and the supplemental arm remains to record that angle, which is read off after the small angle is taken.

Particularly useful when fixing positions in sounding and the boat or vessel is moving quickly.

3107b. Improved Sounding Sextant. To enable the observer, when sounding from a moving boat or vessel, to take both angles in fixing a position, without delaying to read off one angle before taking the other. *Capt. J. E. Davis, R.N.*

When used, the pawl of the indicator is attached to the movable arm and moves with it. When the larger angle has been taken, the finger is applied to the capstan-headed screw, which at once clamps the indicator and frees the pawl from the arm, the smaller angle is then taken and read off; the arm is then moved up to the indicator and the larger angle read off; the capstan-headed screw is then loosened and the pawl drops, connecting the indicator again with the arm.

3107c. Improved Sextant. For observing and recording a number of observations without the necessity of reading off at the time of observation, or removing the eye from the telescope, effected by means of a micrometer movement affixed to the tangent screw, and indicators applied to the arc.

Capt. J. E. Davis, R.N.

It is particularly adapted for observing lunar distances, circum-meridian altitudes, equal altitudes for time. For position in bad weather, &c.

Its advantages are:—

1. It enables the inexperienced observer to take observations with as much facility as the more practised.
2. By greatly multiplying the number of observations, the instrumental and personal errors are reduced to a minimum.
3. At sea, it enables a number of observations to be made in a short time without being dependent (as is often the case) on one.

4. The differences of the altitudes being all equal, the check on the time-taker is apparent.
5. For night observations it is peculiarly adapted.
6. The micrometer movement can be thrown out of gear at pleasure.

The sextant has been submitted to the Astronomer Royal, who states that "*the arrangement is simple, very little liable to get out of order, and I should think very effective.*"

The many sources of error to which the astronomical sextant is liable, either from the different expansive qualities of the materials of which it is composed or the mechanical difficulties attending its construction, render it a less perfect instrument than it is generally supposed to be.

There is also a personal error, incidental to every observer with the sextant or any other instrument, and this is frequently augmented in night observations by the necessity of dilating the pupil to the utmost when observing, and suddenly contracting it in reading off by the aid of the strong rays of a bull's-eye lantern.

With these sources of error, any improvement that can be devised to bring either the instrument to a greater state of perfection, or to deduce a greater degree of accuracy from the observations taken with it, is a step in the right direction, and it is anticipated that by the use of the micrometer movement combined with the indicator, the number of observations can be so multiplied as to reduce the error to a minimum.

3107h. Sextant by Syeds, to be used in a fog. *Capt. C. George, R.N.*

The use and design of this instrument is to give a correct altitude when the horizon is obscured by fog, &c., which desirable end is obtained by this quadrant—the addition of a projecting bar, containing a glass level and the bubble floating therein, which, when seen in the horizon vane in connexion with the sun, gives the true altitude.

3107d. Double Telescope Sextant, with reduced arc and natural angles. *Patrick Adie.*

This instrument was invented and patented by Mr. Adie some years ago, but owing to difficulties in simplifying the adjustments, not yet surmounted for lack of time, has not been publicly introduced. It is an arrangement of the object ends of two telescopes, united by a common hollow axis; the rays from each are received on total or other reflecting surfaces placed at an angle of 45° at the centre of either end of this axis, along which each of the reflectors sends the rays at right angles; these rays are received by two other reflecting surfaces, each occupying half the field of the eye-piece. Thus both objects are seen at the same time. A motion—half that of the movable telescope—is given to the eye-piece, to correct the parallax of reflection from prisms placed at an angle of 45°.

3107e. Cary's Improved Edge Bar Sextant. Special construction to prevent expansion or contraction in different temperatures. *Henry Porter.*

3107f. Portable Sextant. *John Browning.*

3107g. Six-inch Sextant. *John Browning.*

3107i. Davis's Quadrant. *H. Porter.*

3107j. Pocket Sextant, by Cary, used by Captain Henry Bristow, of the Quartermaster-General's Department, in making the military maps of the north of Spain, for the use of the British army, under the Duke of Wellington, during the Peninsular war.
H. W. Bristow, F.R.S.

The sextant is a convenient instrument used for measuring the actual angle between any two well-defined objects, in whatever direction they may be placed, so that the angle does not exceed 140°; and without requiring more steadiness than is necessary for seeing the objects distinctly.

The pocket sextant was formerly used in military and maritime surveying, for fixing points and for filling in the details of maps. It has been superseded by the form known as the *box-sextant* (the principle of which is the same as in the larger sextant), which will measure the angle between any two objects to a single minute.

2996a. Rowland's Patent Sextant. Consists of two sextants on the pillar frame principle, mounted parallel, with their faces towards each other, in such a way that one telescope answers for both. One sextant measures angles in a forward direction, the other in a backward, so that if an angle between two points be measured on the larger sextant, and a third point taken between the other two, the angle between this third point and the other two can be measured at one observation, and the sum of these two angles should equal the first. *W. Watson and Son.*

e. MISCELLANEOUS.

3030. Portable Artificial Horizon. Made by H. Porter.
Capt. C. George, R.N.

Its improvement consists, not only in its reduced size and weight, but in its mechanical arrangements, form, and moderate price.

It secures altitudes near the horizon, as low as 3°; saves time, and prevents waste of mercury.

	lbs.	oz.		in.		in.
Large size, weighs in the case -	4	10	measures	9	by	5
Small ,, ,, ,, -	1	11	measures	6	by	3

3035. Inclined Reflecting Horizon, an instrument for travellers. Made by H. Porter. *Capt. C. George, R.N.*

This instrument is used with the usual artificial horizon, to which it may be said to form an appendage or adjunct. By its aid such increased power is given to the sextant and artificial horizon that altitudes of the heavenly bodies can be measured from the zenith to 30° below it, and also altitudes from the horizon to 30° *above* it and 30° below it; this the sextant and artificial horizon have hitherto failed to do. It consists of a glass reflector, supported by a framework, which has its underside ground mathematically level, and this side floats on the surface of the mercury, carrying the reflector at an angle of about 30° with the natural horizon, and when properly made will always float on the mercury at the same angle; it has been tested by numerous observations, with satisfactory results. *See* observations and drawings.

3035a. Capt. George's Improved Portable Artificial Horizon. Made by H. Porter. *Capt. C. George, R.N.*

This combines the reservoir for holding the mercury with the trough for observation, the two being cast in one piece of iron, with a stopcock to let the mercury run from the reservoir into the trough and back again when not in use. This instrument has a perfectly worked parallel glass floating upon the surface of the mercury, thus giving a perfectly brilliant surface and protected from the action of the wind ruffling the surface of the mercury during an observation. This instrument combines the most perfect horizontal surface, with exceeding portability (being less than one sixth the size of the ordinary mercurial artificial horizon) and the greatest facility in use.

3030a. Artificial Horizon, constructed by W. Herbst.
M. W. Herbst, Pulkowa.

M. Herbst's artificial horizon differs from that commonly used in the following points :—It is a box of rectangular shape, the mercury is enclosed in the lower part of the box, and brought up on the silvered copper-plate by means of a screw; it admits of easy cleansing of the reflecting surface without any loss of mercury; its folding rectangular roof is covered with mica.

3030b. Plumb Level, or Artificial Horizon.
Louis Brocher, Geneva.

The instrument consists of a vertical rod, a horizontal disc, and a small suspension chain. In operating, the instrument should be held suspended by the chain, like a plumb-line, the eye being on a level with the disc; the projection of the plane of its upper and lower surface determines the horizon. As the rod is graduated, and as the distance from the eye to the rod can be ascertained by means of a line, the observer can determine approximately the *sine* of the angle of elevation of the object—building, tree, or mountain—and ascertain its height, if not absolutely, at all events relatively. This instrument, which was originally invented with a view of supplying a means (in sketching from nature) of ascertaining in any place the level of the horizon (a matter indispensable for correct perspective), may be, and has already been, useful to architects, engineers, geographers, tourists, and also to agriculturists, for drainage purposes. Its small size renders it easy to carry, and the rapidity with which observations can be taken enables them to be repeated almost without intermission.

3029. Mercurial Barometer, an instrument for travellers. Made by H. Porter. *Capt. C. George, R.N.*

Its peculiarity is, that the tube and cistern are carried empty, the mercury being secured separately in an iron bottle.

The cistern is used as a funnel.

It is filled, when required, by the traveller, using the spiral cord, which is kept in the tube while being filled.

Circular motion is given to the spiral cord, which, acting on the dense body of the mercury, forces the cord upwards, and out of the mercury, and with it the air bubbles, leaving a superior vacuum, as shown by the mercury always having a convex surface whether rising or falling.

A spare tube is in same box.

The instrument has been tested by R. H. Scott, F.R.S., Director of the Meteorological Office, London, and also at the Kew Observatory, with good results. It is now being used by travellers on the African lakes, and various parts of the world.

3055. Compass Theodolite, a representation of an instrument invented by the exhibitor, for observing, with a microscope, the exact position of the magnetic needle.
Prof. Joseph Schlesinger, Vienna.

3064. Cross-Staff, with box-level.
Zimmer Brothers, Stuttgart.

This instrument, cross-staff, with iron rod, angular mirror, and box-level, serves for setting out right angles, made entirely of metal; on stony ground or in frosty weather it is preferable to the cross-staff with wooden pole.

3065. Reflecting Hypsometer.
Zimmer Brothers, Stuttgart.

The cross staff and mirror hypsometer.

The cross staff serves likewise for marking right angles and drawing perpendiculars.

The mirror-hypsometer is used for measuring the height of trees, &c.

These instruments are particularly useful for foresters and agriculturists, on account of their being easily carried about.

(See "Holzmessekunst," by Prof. Dr. Baur, Hohenheim).

3068. Hypsometer (thermo-barometer), graduated in $\frac{1}{200}$ths of a degree centigrade, and in millimetres representing the corresponding tensions of aqueous vapour.
W. Haak, Neuhaus am Rennweg, Thüringen.

3068a. Improved Hypsometer, large, with thermometer for the exact measurement of heights by the vapour of boiling water. *L. Casella.*

3068b. Hypsometer, small, for travellers, with thermometer, for the exact measurement of heights by the vapour of boiling water. *L. Casella.*

3069. Hypsometer for levelling. To ascertain elevations up to 500 metres by observing the boiling point of water.
W. Haak, Neuhaus am Rennweg, Thüringen.

3070. Hypsometer for levelling. To ascertain elevations up to 4,550 metres by observing the boiling point of water.
W. Haak, Neuhaus am Rennweg, Thüringen.

3071. Apparatus constructed for observing the boiling point of water, in the use of hypsometers.
W. Haak, Neuhaus am Rennweg, Thüringen.

3090. Land Surveying Apparatus, of simple construction, by A. Geppert, completed by F. Miller. *F. Miller, Innsbruck.*

This apparatus, chiefly designed for work requiring no particular exactitude, and which a beginner with little experience in surveying may be trusted to execute, consists of a "Nativ," in which a round plank is screwed, and serves as a leaf. On the edge of this leaf are put 4 brass plates, with a deviation scale at distances of 90°, for forming right angles. The distance of the two sights is 30 cm.; one bears two horizontal cords, in the other a little slide with movable sight, which can be moved in a vertical direction. If the index of this slide stands at zero on the division fastened to the sights, the line of sight is horizontal when the tablet of the instrument is put in action. By moving the slide, and measuring the way which has been passed, the instrument can be used for indirect levelling distance and mensuration of heights and tracing. A chord drawn over both sights allows the formation of perpendicular lines.

3090a. Surveying Table, with plummet rule as used by the topographical surveys in Russia.

The Topographical Department of the Imperial Russian General Staff, St. Petersburg.

The plummet rule is provided with an altitude circle, and, besides, arranged as an instrument for measuring distances by adjusting the horizontal strings of the two water-levels which are attached to the plummet rule; the lower one is for regulating the horizontal position of the surveying table, the upper one for regulating the horizontal position of the altitude alhidada, by means of a micrometer screw acting against the beam of the alhidada.

3090b. A. C. Bagot's Patent Clinometer. *A. Apps.*

The object of this instrument is to enable those persons who are engaged in engineering, contractor's work, land agencies, mines, &c. to get sufficient preliminary data with respect to the configuration, &c. of the land as shall warrant a more complete survey later, without having to carry about a theodolite, or Y level, with their various cumbrous appendages.

Foremen platelayers can accurately get the gradients of the railway; the arrow on the brass scale on the right indicates the angle subtended; the arrow on the left simultaneously indicates the number of inches rise or fall per yard.

Thus, if the limbs are opened until the right-hand arrow marks 45°, on referring to the left-hand arrow the number 36 is found; this means a rise of 36 inches per yard, or 1 in 1.

The telescope is reversible and of short focus. Such tables as are frequently necessary when in the field are calculated out, and engraved on the side of the instrument for reference.

The sight of the prismatic compass enables the operator to read off number of degrees, and still keep his eye on the object.

As a draining level for estate work this instrument will be found unrivalled, since an approximate idea of the amount of fall can be got before going to the expense of having the land surveyed, and being told that the fall is inadequate to the purpose.

Mining engineers can solve many problems with this instrument where the Y level could not be set up.

The design and construction, &c. of the instrument is strictly protected by Royal Letters Patent, granted to Alan Charles Bagot, Churchdale, Rugeley.

3091. Jaehn's Polymeter, with plane-table.

Schmidt and Haensch, Berlin.

Jaehn's "polymeter" enables the measurement of the distance of two points, or their relative position in the horizontal direction, and their differences of altitude to be obtained in a mode quite different from previous methods of operation. Both may be effected—1, simultaneously; 2, by one observation;

3, from a single point; 4, without any calculation; 5, by a mechanical setting out of the measured distances and heights in proportion upon the plane of the measuring table; 6, in any scale.

3094. Distance and Altitude Measuring Instrument (telescope ruler), executed, according to the directions of Prof. Helmert, by F. W. Breithaupt and Son, Cassel.

Prof. Helmert, Aix-la-Chapelle.

This instrument is designed for topographical surveys. It has a distance-measure on glass; the altitude-circle is furnished with two verniers, although, as a rule, only one of them need be read off; moreover, the position of the index may be ascertained with the lens without the employment of the vernier. A spirit level is movable together with the vernier arm, a mirror enabling it to be seen from the eyepiece. The instrument also has levels and adjusting screws for the horizontal axis of rotation of the telescope, and parallel ruler.

3095. Triangular Prism.

Geodetic Institute of the Royal Polytechnic School, Munich, Prof. Dr. von Bauernfeind.

The Three-sided Angle Prism, invented by the exhibtor in 1851, serves for the measurement and setting out of right angles, and depends upon the deviation of light by refraction and total reflection. *See* Bauernfeind's "Elemente der Vermessungskunde," 5th edition, 1876, Stuttgart, F. G. Cotta, Vol. I., pp. 37–39 and 164, 165.

3096. Distance-measuring Prism.

Geodetic Institute of the Royal Polytechnic School, Munich, Prof. Dr. von Bauernfeind.

The Distance-measuring Prism, also invented by the exhibitor in 1851 but not applied to measuring distances until afterwards, serves for marking off isosceles triangles in which the equal sizes are definite multiples of the base. It is used in the same way as the three-sided angle prism. *See* Bauernfeind's "Elemente der Vermessungskunde," 5th edition, Vol. I., pp. 39–40 and 167 (No. 4), and Vol. II., pp. 90, 91.

3097. Pentagonal Prism.

Geodetic Institute of the Royal Polytechnic School, Munich, Prof. Dr. von Bauernfeind.

The Five-sided Angle Prism, invented by the exhibitor in 1869, serves not only for the measurement and marking off of right angles and half right angles, but especially for the laying down in position of two inaccessible points, or points which cannot be directly observed. It may replace the prismatic cross No. 3098. *See* Bauernfeind's "Elemente der Vermessungskunde," 5th edition, Vol. I., pp. 44–46 and 166–168.

3098. Prism Cross.

Geodetic Institute of the Royal Polytechnic School, Munich, Prof. Dr. von Bauernfeind.

The Prism Cross was invented by the exhibitor in the year 1851, and was then described in a separate memoir ("Das Prismenkreuz," published by I. Palm, Munich). It is described with later improvements in Bauernfeind's "Elemente der Vermessungskunde," 5th edition, Vol. I., pp. 168–175, especially 173–175. Its object is identical with that of the subsequently invented five-sided angle prism (No. 3097), which, as already stated, may be used instead of it.

3041a. Compass Binocular. *Robert E. Barker.*

A small mariner's compass is fixed between the two tubes of the field-glass. Inside of the cover of the compass case (which is hinged tightly at the edge farthest from the eye, so as to remain set at any angle between 0° and 90°) is a mirror. When the mirror is set at about 45°, the direction in which objects seen through the glass lie, is shown by merely raising the eye and looking at the reflected image of the compass in the mirror.

This combination will be of service to officers of the army or navy, also to exploring parties, travellers, or tourists. With it the compass bearings of any object in the field of the glass can be seen directly in the mirror attached. It adds very little to the weight of the glass, can be fitted to any binocular, and will readily go into the original sling case with it. Rough surveys may be made with it in positions where larger and more costly instruments would not be available.

3042. Clinometer, by General Naeser.
Survey Office, Christiania, Norway.

This apparatus consists of a thin circular brass box, vertically fixed on three screws, by means of which the exact position can be maintained. Through the centre of the box moves an axis, supporting on one side a small telescope, and on the other a needle, following the movements of the telescope, and giving the readings of the tangential scale engraved on the box. By a small change-wheel, the angle between the optical axis of the telescope and the horizon is multiplied 10 times, thus enabling the operator to read off the tangent with sufficient accuracy. The horizontal distance between two objects being known, the difference in height can easily be found. The instrument can be used with advantage for distances up to 15 miles, and generally for all levelling purposes.

3043. Clinometer, by G. Olsen.
Survey Office, Christiania, Norway.

This apparatus consists of a square box, in which a pendulum moves on a horizontal axis. At the lower end of the pendulum a tangential scale is fixed, which doubly reflects in two small mirrors placed over the top of the pendulum. On the outer side of the box a small telescope is fixed, movable in the vertical plane. By directing this telescope to an object whose horizontal distance is known, and by reading off the division on the scale that coincides with the object, the difference in height can be readily found by referring to a table. The instrument needs no corrections, is very handy, and easily transported, but cannot be used at such long distances as the clinometer constructed by General Naeser.

3043a. Casella's Improved Ship's Clinometer, for measuring the inclination of ships or yachts fore and aft or athwart ship. *L. Casella.*

3044. Pocket "Mensor." An improved arrangement or combination of various instruments for measuring and other purposes. *Ridley Henderson.*

This instrument, when folded up, measures 3 inches square by $2\frac{1}{4}$ inches deep, and weighs 2 lbs. 2 ounces.

It contains within a box, hinged together in three parts, twenty instruments, as follows :—Anemometer, aneroid barometer, clinometer, goniometer, thermometer, circumferentor, protractor dial, prismatic compass, hypo-thonite, quadrant, spirit level, limb and sights for taking altitudes, sun-dial, callipers, plummet, magnifying lens, Nicol prism, scale of inches, scale of chains; added to which are arranged two tables of constants and useful formulæ, and an easy method of ascertaining the variation of the magnetic needle.

It is a measurer of time, heat, velocity, and pressure, also of height, depth, length, and breadth; and of horizontal, vertical, acute, and oblique angles.

It is made so portable in form and weight as to enable it to be carried in the pocket, and yet it possesses sufficient size and strength to render it a trustworthy and useful companion to military, civil, and mining engineers, geologists, mineralogists, railway and land surveyors, and travellers.

3108. **Drawing of a Horizontal Goniometer** for determining geographical longitude without a chronometer.

H. Haedicke, Demmin, Pomerania.

The instrument of which this is a drawing serves, in the first place, to determine by direct reading the angle formed by the line joining two stars (*a—b*) with the horizon. The handling of the instrument is for this purpose similar to that of the sextant; that is to say, the moment must be noted when the star line is covered by the hair line of the instrument. That an observation may be carried out on board ship, the instrument is provided with an arrangement which enables the position of the scale with respect to the artificial horizon to be fixed at the moment of the observation, so that the angle can afterwards be read by means of a vernier.

When in this manner the angle of a second star line (*c—d*) to the horizon has been determined, a simple subtraction will give the angle between the star lines *a—b* and *c—d*. Should there be a planet among the stars *a, b, c, d,* it becomes possible, by means of a proper astronomical table, to calculate the astronomical time as well as (if the local time be known) the geographical longitude of the place of observation.

3127. **Instrument,** called **Metrostroph, for the Construction of Altitude Curves** (contours).

Bau Deputation, Hamburg.

This instrument is a variable scale, invented by F. H. Reitz, which facilitates plotting apoint on a contour line from the two nearest points, the levels of which are determined. *See* 3217a.

3151. **Two Levels,** sensitive to show one second of inclination by $\frac{1}{20}$ of an inch in any part of their length. *Adam Hilger.*

These levels were made at the desire of the late Colonel Strange, F.R.S., to stand a hot climate like India, and can be easily filled with ether.

The glass tubes are $9\frac{1}{2}$ ins. long by $\frac{3}{4}$ ins. in diameter and ground to a radius of 1,000 feet. The ends of the tube have glass plates, which are spherically ground and very highly polished, and fit so accurately that no ether can escape, the ends being kept in their places by a spring which has three arms. The ends of the brass-mounts have bayonet joints, so that the level can easily be refilled.

3039a. Collection of Drawings in illustration of the progress in the construction of instruments employed in the science of geodesy, selected from various works published by the contributor.

Dr. Wilhelm Tinter, Professor of Practical Geometry at the I. R. Polytechnic Institute, Vienna.

Illustrations of the Improvements in the construction of Surveyors' or Engineers' Tables.

1. Drawing and description of Praetorius's table (1576–1616), after Daniel Schwenter (1623).

2. Drawing and description of Marinoni's table (1676–1755).

3. „ „ Kraft's table (1827), A., page 334.

4. „ „ Starke's table (1859 and 1873), A., page 336.

Illustrations of the Improvements in the construction of the appliances of sight required in the use of Surveyors' and Engineers' Tables.

5. Drawing of a simple alidade for taking the level towards one side, A., p. 340.

6. Drawing of an alidade for taking the level on both sides, A., p. 340.

7. Drawing of an alidade with mountain side-vanes, A., p. 340.

8. Simple perspective index (or ruler), after Sadtler (1816), A., p. 346.

9. Essentially improved construction of the perspective index, after Kraft (1854), A., p. 352.

10. Improved construction of the perspective index, after G. Starke (1867), A. and C., p. 356.

11. Improved construction of the perspective index, with Stampfer's surveying screw, after G. Starke (1832–1869), E., pages 53 and 55.

11*a*. Perspective index with turning water-poise (spirit level), after G. Starke (1874), M.

Illustrations of the Improvements in the Appliances for Reading the Graduated Divisions.

12. Nunnez, Pedro-Nonius (1497–1577), proposed the employment of auxiliary quadrants, variously divided (1542).

13. Hommel, John (1518–1562), proposed using transversals for dividing a circle.

14. Vernier, Pierre (1580-1637), proposed the employment of Vernier's (Nonius's) graduated scale (1631).

14A. Ramsden introduced the micrometer (or reading microscope, 1777). A., page 135, and D.

Theodolites and Universal Instruments.

15. Simple theodolite for land surveying, after G. Starke. A., page 259.

16. Repeating theodolite, after G. Starke. A., page 273.

17. Astronomical universal instrument, after G. Starke. A., page 133.

18. Astronomical universal instrument, after G. Starke. E., page 39.

19. Astronomical universal instrument, with telescope in the axis for travelling purposes, after G. Starke. E., page 41.

20. Transit instrument, after G. Starke. A., page 212.

Illustrations of the Improvements in the Construction of the Hydrometrical Vane.

21. Oldest construction, after Woltmann (1790).

22. Improved construction, after Sadtler and Kraft.

23. Improved construction, with differential wheels.
24. Improved construction, after G. Starke. E., p. 73 (1870).
25. Improved construction, after Amsler-Saffon (1870).
26. Construction according to Amsler-Saffon with electro-magnetical numbering apparatus (1873). E., p. 73.

Illustrations of the Improvements in the Construction of Planimeters.

27. Polar planimeter, after Amsler (1856).
28. Momentum planimeter (Integrator), after Amsler (1856). A., 4 part, p. 36, E., page 81.
29. Polar planimeter, after Miller and Starke (1856). A., 4 part, page 24.
30. Polar planimeter, after Coradi and Ott (1874).
31. Planimeter Wetli, Starke (1850, 1871). A., 4 part, page 8, E., page 82.

Illustrations of the Improvements in the Construction of Levelling Instruments.

32. Vitruv's water-level (63 before Christ, 14 after Christ).
33. Water-level, after Picard (1620–1682).
34. Water-level, after Huyghens (1629–1695).
35. Water-level, after de la Hire (1704).
36. Water-level, after Rômer (1644–1710).
37. Channel level (Picard).
38. Mercury level, after Keith (1790).
39. Vega's levelling diopter (1754–1802).
40. Liesganig's water level (1719–1799).
41. Sisson's water-level (18th century).
42. Stampfer's levelling diopter (1839). F., page 24.
43^1. Hogrewe's levelling instrument (1800).
43^2. Pocket levelling instrument, after G. Starke. F., page 33.
43^3. English levelling instrument, by Cooke and Son. E., page 65.
44. English universal levelling instrument, by Cooke & Son.
44^2. Levelling instrument, with Stampfer's levelling screw (1836) A., page 197.
45. Universal levelling instrument, with Stampfer's levelling screw, after G. Starke (1867), F., page 146, and G.
46. Universal levelling instrument with telescope, after G. Starke (1867). F., page 174, and H.
47. Tachymeter, after G. Starke (1872). F., page 103, and I.
48. Polymeter, after Jähns (1873). K.
49. Tachygraphometer, after Wagner (1869–1871), constructed by Fennel. L.
50. Aneroid, after Naudet. F., 2nd part, page 35.
51. Aneroid, after Goldschmidt. F., 2nd part, page 49.

The foregoing illustrations are selected from the following publications by Dr. Tinter:—

A. Lectures on elementary geodesy (autobiographies).

A^1. Lectures on the theory and practice of geodetical and astronomical instruments.

B. Mathematical, geodetical, and astronomical instruments (History of Trades and Manufactures and Inventions, 1873).

C. The perspective index, especially with regard to the construction given to this instrument by G. Starke.

D. The micrometer.

E. Universal Exhibition Report on astronomical and geodetical instruments.

F. Lectures on elementary geodesy, Part II.

G. G. Starke's universal levelling instrument, with telescope and Stampfer's surveying screw.
H. G. Starke's Universal levelling instrument with telescope.
I. G. Starke's Tachymeter.
K. Polymeter, by Jähns.
M. G. Starke's perspective index with turning water level.
A. Description of Praetorius's table, according to Schwenter.

3134a. Folding Alhidade or Sight-Vane, small size, for rapid military surveys, with plane table with scales from $\frac{1}{2000}$ to $\frac{1}{20000}$. *M. Georges Sarasin, Geneva.*

This instrument is so constructed as to give, with an approximate exactitude which in no way hinders the rapidity of the work (notwithstanding the reduced size of the instrument for portability), the measure of distances by means of a micrometer, and with the optional assistance of an improvised sight, the measure of inclinations by means of a clinometer furnished with a vernier reading to five minutes, and consequently the measure of the differences of level, as well as a sketch of the horizontal lines on the ground, with the aid of a calculating rule. It is possible to check any inaccuracies of centering by verniers diametrically opposite to one another, and by turning the telescope end for end. There are also means of adjustment and correction.

3134b. Folding Alhidade or Sight-Vane, large size, for topographical surveys, with plane table to scales from $\frac{1}{200}$ to $\frac{1}{2000}$. *M. Georges Sarasin, Geneva.*

The plane table, constructed to give with considerable accuracy, notwithstanding its reduced size for portability, measures of distances by the aid of a sight *stadia*, inclinations by means of a clinometer furnished with a vernier reading to three minutes, and consequently the measure of the differences of level, as well as a sketch of the horizontal lines on the ground, to scales of from $\frac{1}{200}$ to $\frac{1}{2000}$. It is possible to *check* any inaccuracies of centering by verniers diametrically opposite to one another, and by turning the telescope end for end. There are also means of adjustment and correction.

3135. Signalling Apparatus (Aëroclinoscope), by Major Kromhaut. *Prof. Buys-Ballot, Utrecht.*

This apparatus consists of four movable discs and two fixed hollow cylinders. Two of the four movable discs *never* enter the space between the cylinders; the other pair remain *constantly* between the fixed cylinders, but may very easily be placed in six different positions clearly to be distinguished from afar.

The two discs *f i* may be brought very easily close to one another and to the first cylinder or the second cylinder; or they may be more or less separated, one close to one of the cylinders, or both or neither of them. We have then six combinations. Each of the two other movable discs may be hidden, also by another chord, by the cylinder next to it, or be placed close to it or at a double distance. Three positions for each give nine combinations ($6 \times 9 = 54$).

On the whole, when we make use of two pairs of discs we have 54 different signals, visible from far in a very distinct way.

Now, in Holland, the upper outer discs are to represent the barometer-height at Helder, Groningen, and the under outer discs the barometer-height at Flushing and Maestricht, and these form at the same time the direction of the expected wind. They show the azimuth of the gradient (the strike). The two inner discs denote the magnitude of the gradient (the fall).

All these positions are to be seen in the joined diagrams.

3135a. Gauss's Heliotrope, ancient construction.

Geodetic Institute of the Observatory, Göttingen, Prof. Dr. Schering, Director.

3135b. Gauss's Heliotrope, modern construction.

Both instruments were constructed in the years 1821 and 1822.

Geodetic Institute of the Observatory, Göttingen, Prof. Dr. Schering, Director.

3135c. Heliotrope, an instrument for throwing the reflected light of the sun in any required direction.

Prof. W. H. Miller, M.A., F.R.S.

The Heliotrope consists of a plane glass mirror, two adjacent edges of which are ground and polished in planes making right angles with one another and with the large planes of the mirror, and then covered with asphalte varnish. A portion of the silvering, not larger than the pupil of the observer's eye, is removed from the angle where the two small polished surfaces meet the hinder plane of the mirror.

If held in such a position that the sun's light falls in the solid angle between the face of the mirror and the two small polished surfaces, a portion of the sun's light that falls upon the face of the mirror is refracted at the first surface, reflected internally at each of the small surfaces, and finally emerges through the space from which the silver has been removed, in a direction parallel to, but opposite to, that in which the reflected light travels from the large plane of the mirror.

Hence, any point with which the faint image of the sun appears to coincide will receive the light of the sun reflected from the mirror.

3136. Sun Signals, for the use of travellers.

Francis Galton, F.R.S.

The difficulty in sun-signalling is to direct the flash aright. The rays of the sun are reflected from a mirror, in a cone of light precisely similar to that which reaches it, the mirror itself (whose size may be disregarded) being the apex of the latter cone, and the sun's disc its base. It follows, that to the signaller, whose eye is near the mirror, the place where the cone of reflected rays falls on the distant landscape would always appear to him as a disc of precisely the same shape and size as the sun itself. In other words, his accuracy of aim must be within 30 minutes of a degree. In the author's heliostat an image of the sun is produced, which overlies the area on which the flash of the mirror falls. A lens is fixed in the instrument at right angles to the line of sight; half of the lens lies within the tube through which the observer looks, and occupies a portion of his field of view, the other half is external to his field of view; it projects beyond the side of the eye tube, and receives the flash of the mirror. The mirror turns on an axis attached to the tube, which allows it movement in one direction, while the rotation of the entire instrument in the hand gives movement in the other. When the mirror is so adjusted that the reflected (parallel) rays from any one point of the sun's disc impinge on the lens, they are brought to a focus on the screen, and form a minute speck of light upon it. Rays radiate from this speck in all directions, and those that strike the part of the lens inside the eye tube, are reduced by its means back again to parallelism with the rays that originally left the mirror. Consequently the eye, looking down the tube, sees a bright speck through the lens, which it refers to the same distant point in the landscape seen to the side of it, as that to which the unobstructed rays from the mirror are being flashed. If a telescope be fitted to the tube the speck would overlie the spot on the landscape. Now what is true for any one point in the sun's disc is true for every point, therefore the signaller sees a luminous disc in his field of view, and this exactly overlies the *locus* of the flash. By gently rotating the hand the image can be made to cover or to forsake any point in the landscape that may be desired, and when that is done an observer stationed at that point will see a succession of flashes. Morse's alphabet can be adopted. A flash passing through a square hole of only one-third of an inch in the side, is visible to the naked eye at a distance of 10 miles, if the background be dull and the air perfectly clear. The principle of this heliostat was described in a memoir read before the British Association in 1858.

3137. Optical Telegraph, by Colonel Laussedat, composed of a transmutor and of a receiver, with their stands.

Colonel Laussedat, Paris.

The principle of this optical telegraph is due to Professor Mauras. Several other scientific men, during the siege of Paris in 1870–71, and since have assisted, under the direction of Colonel Laussedat, in modifying and perfecting the construction of the original apparatus. The model exhibited is the one which Colonel Laussedat proposed for country telegraphs and for the application of luminous signals to geodesy. When the sky is cloudless, recourse can be had to the rays of the sun; when the case is otherwise, one must be contented with the flame of the petroleum lamp, of which the range is far more limited. By night its range increases considerably, so much so that when the two small lanterns are exposed it is possible to send and receive signals at a distance of more than 40 kilometres; the communication takes place by means of luminous flashes and eclipses effected by a small screen, worked by the sender of the message. The Morse alphabet can be used by using short flashes for the points, and longer flashes for the lines. The working of the instrument can quickly be learnt, and this very simple apparatus is most useful in cases where the electric telegraph is wanting.

3138. Models illustrating two methods of **verifying Sextants** employed at the Kew Observatory:—

1st. By flashing the sun's rays to distant mirrors, whereby stars of light were visible to the operator at the testing table. This was ceased to be employed on account of the rarity of sunshine. Designed by F. Galton, F.R.S.

2nd. A system of five collimators, fixed firmly to a wall on a circular arc, arranged so as to send parallel rays across the testing table at known angles. Designed and constructed by J. Cooke, and described in the Proceedings of the Royal Society, vol. XVI., page 2.

Kew Committee of the Royal Society.

3099f. Prismatic Compass, with improvement of ring to hold more safely in the hand. *Henry Porter.*

3034. Pocket Compass, for bearings of objects, &c., an instrument for travellers. Made by O. S. Bishop.

Capt. C. George, R.N.

A combination of the ordinary compass and the dipping needle. The advantage aimed at is, that it will act at or near the magnetic pole when the ordinary compass ceases to be of any use.

3032. Universal Tripod Stand, an instrument for travellers. Made by H. Porter. *Capt. C. George, R.N.*

May be used for five instruments, viz.:—

Sextant (for Lunars).
Telescope.
Barometer.
Prismatic compass.
Artificial horizon.

3139. Spectacles for **Divers,** for use in water.

Francis Galton, F.R.S.

When we look down into still clear water we see all objects in it with perfect distinctness, but the moment that the open eyes touch the water all distinctness of vision ceases. The convex surface of the eyeball has indented the plane surface of the water with a plano-concave lens, and, if we desire to restore distinctness of vision, we must use convex glasses of sufficient power, when immersed in water, to neutralise this effect. A double convex flint glass, each of whose surfaces has a radius of about half an inch, is therefore required. By means of the glasses exhibited it is possible to read the smallest type under water, with perfect ease. The principle of these glasses was described in a memoir read before the British Association in 1865.

3140. Ground Tongs for **Sea Soundings;** invented by Francis Hopfgartner, Austrian Imperial and Royal Naval Officer of the line. *Lieut. Hopfgartner.*

A hole is bored lengthways through the centre of an ordinary plummet. In this hole is inserted a movable metal rail, at the lower end of which there are attached two scoops or spoons, opening and closing by means of a hinge or link. At the upper end there are two movable bows which are joined to the ladles by small chains. If the plumb-lead is suspended to these hook-like bows by means of two short auxiliary lines, the scoops are opened and the apparatus is then ready to be let down into the water. On reaching the ground the bows will fall back, dropping the auxiliary lines, the weight of the lead presses the scoops into the ground, and by pulling up the main plumb-line, which is now acting directly on the metal rail, the scoops are closed and drawn into the hole of the lead so far as to be securely closed.

3141. Ground Tongs for **Sea Soundings,** with disengaging weight; invented by Francis Hopfgartner, Austrian Imperial and Royal Naval Officer of the Line. *Lieut. Hopfgartner.*

Two scoops or spoons, intended for securing specimens of the sea bottom, are opened and closed like a pair of tongs by means of two levers. A peculiar metal cover, in which the ladles will fit, secures the closure of the same. At the upper ends of the two limbs of the tongs there are two hook-like movable bows, on which the lead is placed, which, on the apparatus being let down into the water, keeps the scoops in an open position. On reaching the ground the bows will drop back, the weight (stone or a ball) will fall off, and the metal cover will encase the scoops, and keep them closed while the apparatus is being pulled up.

3142. New Lead for **Deep-sea Soundings;** invented by Francis Hopfgartner, Austrian Imperial and Royal Naval Officer of the Line, and Moritz Arzberger, Civil Engineer at Vienna.
Lieut. Hopfgartner and Moritz Arzberger.

The exterior form of this apparatus is that of a tube, of which the lower part forms the contrivance for throwing off the weight, while the centre part contains the indicating apparatus, being a system of metal cases which, through the pressure produced on them by the water, indicate the depth on a scale. The upper part is an arrangement for propelling the apparatus upwards in case the lead is to be used without a line.

3142a. Sinker and Tube with Detaching Appliance for Sir William Thomson's Pianoforte Wire Sounding Apparatus. *Sir William Thomson.*

The pianoforte wire (No. 22 B. W. G. Webster and Horsfall's) weighs about 14½ lbs. per nautical mile (6,086 feet) in air, or 12½ lbs. in water.

The strength of this wire to resist pull is such that it bears about 230 lbs. (104 kilogrammes) weight in air, or 29·4 kilometres (or 15·9 nautical miles) of its own length.

The splice, a specimen of which is shown, is made as follows:—The two pieces of wire to be spliced are first prepared by warming them slightly, and melting on a coating of marine glue to promote surface friction. About three feet of the ends so prepared are laid together and held between the finger and thumb at the middle of the portions thus overlapping. Then the free foot and a half of wire on one side is bent close along the other in a long spiral, with a lay of about one turn per inch, and the same is done for the free foot and a half of wire on the other side. The ends are then served firmly round with twine, and the splice is complete.

To the lower end of the wire a ring weighing about ½ lb. is attached, and a chain of two fathoms long, weighing 3 lbs., is shackled to this ring. The lower end of this chain bears an elastic wire double claw. The weight is spherical, with a perforation for the tube and two indentations for the two claws, by which it is hung till it reaches the bottom. The moment its weight is taken off by the bottom and removed from the claws, they spring out and leave it free; but before this is done it presses the tube into the ground by means of a bolt attached to the tube. This bolt is kept by a slight spring in its place until the wire is hauled up. During the time the wire is going down, the tube is kept from falling by this bolt, which after the tube touches the bottom, presses it downwards into the mud. When the wire is hauled up, a piece of small cord two or three inches long, connecting the lower end of the chain with a lever arm belonging to the bolt, which was loose so long as the weight hung by the claws, becomes tightened and draws out the bolt. This leaves the tube free to come away from the weight, and it is drawn up by the cord, chain, and wire.

Two specimens of the apparatus are exhibited, one showing the weight hanging on the claw with the tube resting on the bolt just before touching the ground; the other showing the weight supported partly by the bottom and partly by the tube pressed into the bottom (supposed to be mud) and the cord scarcely yet tightened enough to draw out the bolt.

3142a. Sea Sounding Apparatus (Bucknill and Casella's Patent), for the exact measurement of depths in the sea, unaffected by the influence of currents however strong. *L. Casella.*

3142b. Massey's Hand Lead and Deep-sea Sounding Machine. *E. Massey.*

3144. Deep-sea Water-raising Apparatus, according to Dr. Meyer.

Ministerial Commission for the Scientific Examination of the German Seas, Kiel.

3145. Deep-sea Water-raising Apparatus, according to Prof. Dr. Jacobsen.

Ministerial Commission for the Scientific Examination of the German Seas, Kiel.

Intended to bring up with certainty a sample of water from any depth in the sea.

3146. Deep-sea Water-raising Apparatus.

L. Steger, Kiel.

3147. Map Drawing Instrument. *A. Bonsack, Berlin.*

Instruments of this kind have come into use in the province of Schleswig-Holstein.

3148. Coast Station Areometer Case.

Ministerial Commission for the Scientific Examination of the German Seas, Kiel.

The Station Areometer gives the specific gravity of sea water compared with distilled water of + 14° R. within 0·0001.

3149. Two Sets of Ship Areometer Cases, for oceanic voyages,

Ministerial Commission for the Scientific Examination of the German Seas, Kiel.

The Ship Areometer gives but half as accurate results as the preceding; it is characterised by its shortness, which renders manipulation more convenient on board ship.

3150. Two Sets of Ship Areometer Cases, for voyages in the east part of the Baltic.

Ministerial Commission for the Scientific Examination of the German Seas, Kiel.

3145. Slow-Thermometer, in ebonite, for measuring the temperature of the sea.

Ministerial Commission for the Scientific Examination of the German Seas, Kiel.

The Slow Thermometer furnishes very accurate readings when it can remain in the water for an hour. For moderate depths it is more certain, cheaper, and more durable than registering instruments.

3145a. Apparatus for ascertaining the Temperature of the Sea at various depths.

J. L. W. Dietrichson, Christiania, Norway.

The temperature of the sea at different depths cannot always be ascertained with a maximum and minimum thermometer, because it does not constantly increase or decrease with increase of depth.

Supposing the temperature to be: at the surface, 15°; at 200 metres, 6°; at 400 metres, 8°, it would not be possible to gauge this last temperature with a maximum and minimum thermometer.

An apparatus must then be used which shall, in the water and out of the water, preserve the observation taken at the depth.

The apparatus now submitted supplies this want, and also enables the temperature at different depths to be ascertained very easily by a single immersion

The principle is this :—

Two points, 0° and 20°, are accurately marked upon a small thermometer tt (Fig. 1) $c\ 8^{cm}$ long.

If its tube be filed at a given point (x), it will easily break there. A column of mercury, length = xy, will therefore remain in the broken part of the tube. By the outer pressure of the atmosphere, this column will be slightly forced into the tube. If the tube is afterwards exposed to another temperature, the variation resulting therefrom, as affecting the length of the mercury column, will be almost imperceptible. To ascertain the temperature at the time of rupture, it is calculated upon a scale where the distance CD is divided into 20 equal parts. Each part, therefore, will indicate the length of a degree. For instance, if it be seen that the point x is placed at + 6°, and that the length of the column is = 14 parts of the scale, it follows that the temperature at the moment of rupture was = 14 + 6 = 8°.

To effect the rupture of the tube at great depths without the registration of the thermometer being affected by the outer pressure, often enormous, the thermometer is encased within a metal wrapper, as proof as need be, and which can easily be fastened to the lead line by metal wires M and N, shaped corkscrew-wise.

After fixing the thermometer with a screw (z), the ball upwards, between the two cheeks (VH), (Fig. 2), the plan of which is seen only from the back, the filing is done at point x, and the top part AB of the wrapper is tightly screwed up. The bottom part D forms a kind of hinge, covered over with an india-rubber pipe to prevent the water penetrating into it.

The apparatus being sunk at the required depth, sufficient time is allowed for the thermometer to attain the temperature of the surrounding water. A heavy ring is then dropped down the lead line. This ring, following the apparatus through its entire length, strikes the lever CF, which swings, and pressing upon the hinge occasions the rupture of the tube by the sharp end RS, which runs up within the apparatus.

To prevent the hinge being unduly displaced, it is barred by the screw K, which is removed just as the apparatus is plunged into the water. Likewise, to prevent the tube being broken by any unforeseen shock to the apparatus, it is fixed between two india-rubber strings (V), drawn between the two cheeks which support the thermometer.

2909a. Seismochronograph, designed by the exhibitor.

Prof. Dr. von Lasaulx, Royal University, Breslau.

1. The instrument is screwed on, inside, to the back of the station regulators * in such a manner that the pendulum, when the ball is resting on the plate intended for that purpose, and, consequently the lower arm of the lever is directed downwards, can swing past this latter, but is arrested immediately without making any further vibratory motion when the ball is thrown off through concussion, or by shaking, and the lever shifted thereby before the pendulum.

2. The instrument must be screwed on very firmly to the back partition of the regulator, in order to prevent the possibility of spontaneous action.

3. By putting up the instrument the eight round recesses designed for receiving the ball when thrown off must be marked according to their actual position towards the regions of the heavens. The best contrivance will be to engrave the letters N., N.E., E., S.E., S., S.W., W., N.W. on the border, so that the section marked N. actually points towards the north.

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* In places where there is a station clock without a case, the instrument must be fastened to the wall.

4. Each time the ball is thrown off (provided there is no other circumstance, such as winding up or regulating the clock, to cause it) is noted on a separate sheet (see the annexed form) with the exact date, the time and hour of the day, and the direction in which the ball was thrown off by naming the recess with its corresponding letter in which the ejected ball was found. In places where there are clocks indicating seconds the time must be noted to seconds, otherwise by noticing as accurately as possible the fractions of the minutes.

5. After each reading the ball is placed again directly on the plate, the clock set in motion, and immediately correctly adjusted, if possible.

6. In case of greater commotions of the earth, or shocks of an earthquake, which can be recognised as such also without apparatus, a report as to the time and direction must *immediately* be submitted to the general administration of the telegraph service by the telegraph branch office concerned.

7. All other movements or disturbances which are being indicated by the instrument are registered, as above, and sent in monthly, or, if nothing have occurred, a report to that effect.

8. Particular attention must be paid to the *daily* careful adjustment and regulation of the clocks according to the directions given, in order to render the instruments useful.

OBSERVATION of an EARTHQUAKE by means of the SEISMOCHRONOGRAPH designed by Von Lasaulx, at the Imperial Telegraph Station at

1. Date of Observation.	2. Time and Hour of the Day.				3. Direction of the Commotion or Shock, according to the Position of the ejected Ball.	4. What kind of Shocks or Commotion.	5. Duration of the Phenomenon (whether actually observed or estimated).	6. Simultaneous, Preceding, or Succeeding Noise.	7. Special Remarks (as to Damages, Injuries, &c.).
	Time of the Day.	Hour.	Minute.	Seconds.					
1875, Aug. 29.	a.m.	9	40	30	The ball was found lying in the recess directed towards N.E. External observation seemed to confirm that the shock came from that direction.	Not so much undulating as abrupt movement; one shock apparently, with wavering after vibration.	From about 2 to 3 seconds (as per estimation).	Dull, hollow, thunderlike noise following immediately after the shock.	A high chimney of a manufactory at fell in the direction towards N.E. Some houses were damaged, receiving cracks, not in the middle of the walls, but in the vicinity of the window panes. The phenomenon was undoubtedly recognised as being an earthquake, and was very violent, &c.

2909b. Mallet's original Seismometer.

R. Mallet, C.E., F.R.S.

IV.—COMPASSES.

3151a. COMPASSES, ADMIRALTY PATTERN, IN USE IN HER MAJESTY'S NAVY.

EXHIBITED BY THE ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

Admiralty Standard Compass. Tripod; azimuth circle; light and heavy cards; spare cap and pivots. Used for steering and taking bearings.

Plain glass cover when the compass is used for steering. Cover and azimuth circle, for taking bearings, with the card read with a prism, and graduated for measuring horizontal angles. Light card, four compound needles of two laminæ each; ruby cap; pivots two of hard steel, two pointed with native alloy. Heavy card, four compound needles, two of four laminæ, two of two laminæ; cap of speculum metal; pivots pointed with ruby. Tripod and sprang, for use of compass on shore.

This compass can be allowed to rest on india-rubber suspension, by turning the screws marked F and A; it has the effect of steadying the card when the compass is exposed to vibration.

Prismatic Azimuth Compass, with tripod, card, spare cap, and pivots. Used for taking bearings on shore, and as a standard compass for small vessels. Card with two compound needles, of two laminæ each; agate cap; pivots of hard steel. Tripod for use on shore.

Steering Compass, large size; with card and spare pivot. For large vessels, card with four compound needles of two laminæ each; cap of speculum metal; pivot pointed with ruby.

Steering Compass, small size, with card, spare cap and pivots. For small vessels. Card with two single needles; cap of agate; pivots of hard steel.

Dent's Liquid Steering Compass. For use when the card of the ordinary compass becomes unsteady.

Liquid, two-thirds water, one-third alcohol. Air chamber round upper rim, to allow for the expansion of the fluid from temperature; aperture for filling when fluid has wasted. Lifter for raising the card off its pivot when required.

West's Liquid Steering Compass.

Liquid, of same composition as Dent's. Bowl hermetically sealed, the expansion of the liquid being provided for by having the bottom of the bowl made of flexible corrugated metal.

Boat's Liquid Compass, in binnacle, with lamp. For use in boats.

Construction, the same as Dent's Liquid Steering Compass.

Life-boat Compass, in binnacle, with lamp. For use in life-boats.

Construction, the same as Dent's Liquid Steering Compass.

Sledge Compass. Used in Franklin's search-expedition (1850–53).

Card with single needle capable of being moved round under the card, according to the magnetic variation, so that the North on the card coincides with the true North. A light needle in case attached to shoulder strap, for use without card when the horizontal force is weak. Spare card in cover, and directions for use.

Sledge Compass, as furnished to Arctic expedition (1875).

Card with single needle capable of being adjusted to the meridian. Aperture in leather, so that line of direction may be seen without opening cover. Ivory lifter.

Small Azimuth Compass, as furnished to Arctic expedition (1875). For determining the variation of the compass.

Single needle; alloy pivot; ruby cap; graduated circle of alumina metal; sight-vane, and prism.

3151b. MARINERS' COMPASSES OF VARIOUS DATES AND PATTERNS: GENERALLY OBSOLETE.

EXHIBITED BY THE ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

Chinese Compass. Very small needle resting on steel pivot; cover of talc.

Walker's Meridional Compass; with apparatus for determining the latitude when the sun is on the meridian, also the sun's altitude, and hour angle.

Crow's Liquid Compass (Patent 1813).

Card hollow, convex lens shaped, buoyant and pressing upwards against the pivot. Expansion of liquid provided for by air chamber round upper rim of bowl; also by a spring valve allowing the escape of expended air and refilling when required. In the original patent the liquid was entirely alcohol.

Pope's Dipping Needle Compass (Patent 1820); with arc showing dip of the needle.

Graydon's Celestial Compass (Patent 1824); with apparatus for determining the latitude, the angular distance between celestial objects, and their true azimuth.

Danish Azimuth Compass; with telescope for observing distant bearings.

Steering Compass, by Sir William Snow Harris (about 1831); with stout copper ring, to calm vibrations of needle.

Preston's Liquid Compass. A steering compass; same construction as Dent's without air chamber.

Dent's Axis Compass (Patent 1844). Card with four heavy and deep needles, attached to axis working in socket above and below, preserving card parallel to surface.

Steering Compass, by Captain Walker, R.N. Card with single needle, centre of gravity below point of suspension; pivot long and on a brass bell-shaped cap, the latter cap working also on a pivot.

Grey's Vertical Compass (Patent 1854). Liquid between outer and inner bowls; card with two dipping needles; pivot inverted.

Gowland's Liquid Compass (Patent 1854). Rim of card vertical; pair of needles; pivot inverted.

Compass by Mr. Keen (Patent 1854). Porcelain bowl; card two single needles; pivot on springs inverted; cap centred in india rubber ring.

Magnets used in correcting ship's compasses. Hardsteel; 6 inch; 10 inch; and 12 inch.

SPECIMENS OF THREE DIFFERENT SIZES (4-INCH, 6-INCH, 8-INCH, 10-INCH) OF MARINER'S COMPASS, WITH SUN AND STAR AZIMUTH MIRROR, AND BINNACLE CONTAINING CORRECTORS FOR QUADRANTAL SEMICIRCULAR AND HEELING ERRORS.

Sir William Thomson.

3145b. I.—Binnacle, with correctors for quadrantal semicircular and heeling errors, with mirror azimuth instrument on bowl, for taking bearings of sun, stars, or terrestrial objects. Small size compass (4-inch card), suitable for armour-clads or other ships, with quadrantal error exceeding 11°.

3145c. II.—6-inch Compass Card, suitable when quadrantal error is from 7° to 11°.

3145d. III.—Medium size (8-inch card) suitable for standard or steering compass in any ship, iron or wooden, steam or sailing, having quadrantal error less than 7°.

3145e. IV.—Large size (10-inch card) suitable for standard compass when quadrantal error does not exceed 5°.

In the improvements here illustrated the object primarily aimed at was to obtain a compass to which the Astronomer Royal's correctors could be applied with safety and convenience. The quadrantal correctors must not be so near the needles of the compass as to sensibly affect its direction through magnetization of the soft iron by the influence of the needles, otherwise the quadrantal error will, if truly corrected in middle latitudes, be over corrected in high magnetic latitudes, and under corrected in low magnetic latitudes. Thus when the 12-inch iron cylinders of the Liverpool Compass Committee are applied with their ends at a distance of 7 inches from the centre of an Admiralty compass card in this country, they correct a quadrantal error of 12½°, but of this 7½° is due to magnetization of the iron by the compass needles, and only the remainder or 5° is genuine, that is to say, dependant on the magnetization of the correctors by the terrestrial magnetic force. Blocks of iron weighing many tons would be necessary to safely correct for all latitudes a quadrantal error of even so moderate an amount as 5° or 6°, when the compass needles are of so great magnetic moment as those of the Admiralty standard compass. But if, as in the several sizes of compass now exhibited, the needles are of thin steel wire from an inch and three quarters to three inches long, a quadrantal error of any amount not exceeding 21° may be corrected perfectly in all latitudes by a couple of globes of iron of not more than 6 inches diameter fixed on two sides of the compass.

To correct a quadrantal error of 21½° a couple of globes, each 6 inches in diameter, fixed on the two sides of the binnacle at a distance of 6 inches asunder may be used, with the bearing point of the compass midway between them. Hence, to allow room for the case containing the compass, and for the gimbals supporting it, the diameter of the compass card must not be more than 4 inches (I.). This is the smallest of the four sizes now exhibited.

When the quadrantal error is 11° the globes, if of 6 inches diameter, must be placed 9 inches asunder and the 6 inches diameter compass card (II.) may be used. If with the same size of globes the distance asunder is 12 inches the quadrantal error corrected is 6⅓°, and, therefore, when the quadrantal error is of this amount or anything less the 8-inch card (III.) may be used.

The binnacle exhibited is suitable for 4-inch or 6-inch compass cards. It contains two adjustable magnetic correctors for the semicircular error, one for neutralizing the athwart ship component, the other the fore and aft component of the ship's magnetic force. The athwart ship corrector suffices to correct an error of about 23°, whether to port or to starboard, when the ship's head is north or south; the fore and aft corrector corrects an error of like amount when the ship's head is east or west. The binnacle also contains, in the four edges of its square top, provision for placing securely a pair of bar magnets athwart ship and another pair fore and aft in convenient positions a little below the level of the compass card; the former pair to be used when the athwart ship component of the ship's magnetic force, the latter when its fore and aft component exceeds the amount neutralizable by one or other of the adjustable correctors. Thus the binnacle with its several appliances now exhibited supplies convenient means for thoroughly carrying out the complete system of compass correction set forth by the Astronomer Royal in his paper on the correction of the compass, published in the Transactions of the Royal Society for 1839, according to the following very simple rule in three parts, as follows :—

I. Place the ship's head north or south magnetic and bring the compass to point correctly by the athwart ship correcting magnets.

II. Place the ship's head east or west and bring the compass to point correctly by the fore and aft correcting magnets.

III. Place the ship's head N.E., or S.E., or N.W., or S.W., and bring the compass to point correctly by the quadrantal correctors (a pair of 6-inch globes now recommended).

The whole process may be thoroughly performed with all needful accuracy for a new ship in a quarter of an hour; though of course it will be desirable to take an hour or two for verifying or perfecting the correction by testing it on other points than the three on which it was first made. When the quadrantal correctors have been once accurately placed they have never again to be changed for the same ship, and the same place in it (except of course in the case of taking on board a cargo of iron or introducing or shifting masses of iron so near the compass as to sensibly modify the quadrantal error). At any time afterwards the semicircular error (which is always liable to change through changes of the ship's sub-permanent magnetism, and also through change of magnetic latitude in the course of a voyage) is readily annulled by placing her head north or south and using the athwart ship corrector, and again east or west, and using the fore and aft corrector. In a steamer this may be done at sea on any clear enough night to allow stars to be seen, or day when the sun's altitude does not exceed 50°. When the weather is moderate enough to allow her to be steered steadily for two or three minutes first on one and then on the other of the two cardinal points nearest to her course, the detention at worst (that is, when the course is on one of the cardinal points) need not exceed five minutes.

The binnacle also contains an appliance for an adjustable magnet below the compass in a line through its centre perpendicular to the deck, for correcting the heeling error in iron sailing ships.

Each magnet supplied for this purpose is in two parts, joined together by a hinge or chain, so that when out of use they cannot be placed in the box provided for containing them without folding them together with unlike poles close one to the other, so that wherever they may be placed in the ship, they cannot disturb any of the compasses. A stout bar magnet brought carelessly on board a ship without this precaution may be as dangerous as dynamite.

An important objection had weighed with the Compass Department of the British Admiralty against the use of quadrantal correctors in the navy. It was, that they would obstruct the taking of bearings of celestial or terrestrial objects for the purpose of correcting the compass or of terrestrial objects for the navigational use of it. On this account the mirror azimuth instrument now exhibited was designed. It not only does away with that objection to the application of quadrantal correctors, but it is much more convenient for ordinary use at sea than the prismatic arrangement hitherto in use. It facilitates very much the taking of star azimuths by throwing (as in the *camera lucida*) an image of the star upon the divided circle of the compass card, illuminated by the ordinary binnacle lamp), or more properly speaking, on a virtual image of this scale at an infinite distance as seen through a convex lens. It is easy when there is not much motion in the ship to read the positions of the star accurately to a small fraction of the white space between two dark degree divisions on which its image is seen. The focal length of the convex lens is a little greater than the radius of the circle, and thus for objects on the horizon or at any altitude not exceeding 30°, no farther adjustment of the azimuth appliance than just to bring the object fairly into the field of view is necessary.

The compass consists of a light aluminium boss, with a central sapphire cap (by which the compass is supported on an iridium point), and a rim of aluminium of from 4 to 10 inches diameter, according to the size of the compass. There is an even number of holes in the rim, and half that number in the circumference of the boss. The rim and boss are connected together by means of fine silk threads forming, as it were, 32 spokes, and the compass-card is partly supported by these threads and partly by the rim. Two or four small magnets having their corresponding ends tied together by silk threads of equal lengths, so that the magnets may be as nearly parallel as possible, are attached to the rim by means of four silk threads.

The compass thus obtained, being extremely light, and having a large radius of gyration, has very small frictional error, with small enough magnetic movement to give a very long period of free vibration. The smallest compass (I.) has just about the same period of free oscillation as the Admiralty standard compass, and the same quality of steadiness at sea, while the larger sizes have considerably longer periods of from 28 to 43 seconds, and therefore much greater steadiness at sea.

3145aa. **Marine Equatorial** for **correcting Compass** by the **Sun.**

Sir William Thomson.

A circle corresponding to the earth's equator is set upon gimbals with adjustment, by which the inclination of the circle to the vertical is made equal to the latitude of the place. A lens is mounted on a doubly-pivoted frame, which keeps its centre on the centre of the equatorial circle while allowing the lens to turn round its own diameters through this point.

Part of the arrangement for effecting this consists of an outer frame, which has a motion round an axis perpendicular to the equatorial circle. This outer frame carries a portion of a spherical surface arranged as a screen to receive the sun's image during an hour. This screen is marked with declination circles, and these declination circles are divided by portions of meridional circles into spaces corresponding to five minutes of time. When the instrument is set with the axis of the equatorial circle truly parallel to the earth's axis, the sun travels along the declinational circle corresponding to his declination at the time. The frame carrying the screen is turned into such a position that the two extreme meridional circles of the screen agree with numbers on the equatorial circle, corresponding to the integral hours of apparent time before and after the time of observation. Then the instrument is turned in azimuth till the sun's image falls on the proper declination circle, and the point of it corresponding to the apparent time at the moment of observation. If there are no instrumental errors and if the adjustment for latitude is perfectly correct, then it is sufficient to set the instrument in azimuth till the sun's image falls with absolute accuracy on the proper declinational circle. Besides showing the true North, the instrument then shows as a sun-dial the apparent time, or if the apparent time is known with perfect accuracy, and the instrument is turned in azimuth till the sun's image is brought to mark correctly the apparent time, then the instrument shows the sun's declination. In practice both indications are looked to. When the instrument is used in equatorial regions, however, it is solely or almost solely by the sun's declination that it is set so as to give the true North.

In high latitudes, North or South, it is almost wholly from independent knowledge of the apparent time that the instrument is set. Generally the directions to the navigator using it are to set it to agree as well as he can both with the apparent time and with the sun's declination.

The instrument now exhibited has been tested at sea on board the Cunard steamers "Russia" and "Scythia" in voyages from Liverpool to New York and back, and has been found to act well for the purpose for which it was designed. It is, however, defective, and inconvenient in several details, which will be improved in instruments of the kind to be made in future.

3131. Photograph of Paugger's Patent Dromoscope.
Dr. F. Paugger, Trieste.

This dromoscope is circular, and has almost the shape of the ordinary chronometer.

It is about 22 centimeters in diameter, and 7 centimeters in height. On the upper part there is a fixed compass card, with two hands, besides a graduation reading to 45 degrees to the right and left, which lies below these hands (scale of deviation and variation). The inner mechanism of the instrument is a perfect calculating machine; it exhibits for any desired course the exact tangent formula of the deviation of the compass when the contrivance for turning it has been put in motion. On the lower or back part of the instrument there are five scales or graduations marked A, B, C, D, and E; and corresponding with these graduations are five set screws (not visible in the photograph). With these adjusting screws, and the scales belonging to them, the five co-efficients of deviation for any ship can be indicated.

By means of this instrument the deviation of the compass, either of the course or azimuth, is indicated merely by stopping the hand.

A printed description accompanies the instrument.

Compass, made in Venice in 1564 by Antonio Blanchini, watchmaker.
The Royal Institute of "Studii Superiori," Florence.

Nautical Compass, made in 1607 by Baldassare Lancaeuj, of Urbino. *The Royal Institute of "Studii Superiori," Florence.*

Goniometric Compass, of Paolo Massucsiuj, of Lucca.
The Royal Institute of "Studii Superiori," Florence.

3099b. Normal Compass of the Imperial German Navy, with stand, sights, two compass-cards, &c. *Carl Bamberg, Berlin.*

The normal *card A.* of the normal compass is arranged for reversal so that at any time a determination of the error of collimation of the zero-line to the axis of the needle may be effected, and we are enabled to make a determination of the collimation of other cards of ordinary construction, but of the same diameter, by comparison. For measurements on land the gimbals may be fixed and the compass itself be brought to a horizontal position by means of screws.

3099c. Boat's Compass, adapted to be employed as a small azimuth compass. *Carl Bamberg, Berlin.*

The case of the boat compass serves for its transport, and also (by the removal of two pieces) as a binnacle, thus making it a small, handy, and accurate azimuth compass.

3099d. Boat's Fluid Compass. *Carl Bamberg, Berlin.*

The card of the fluid compass is furnished with a float, so that pressure, and therefore also the friction on the pivot, are reduced to a *minimum.* The cap and pivot are made of ruby, so that they do not easily wear, and a stop becomes unnecessary.

3099e. Albini's Registering Steering Compass.
Elliott Brothers.

The instrument consists of a steering compass, with clock and apparatus attached, for printing on a slip of paper the direction of the ship's course every five minutes, the clock giving the exact time for eight days without winding. An instrument of this description placed in the captain's cabin would thus enable him to have a record of a whole voyage.

3099a. Portable Compass. *Colonel Degen, Bobruisk.*

3151. Azimuth Compass, by Brauer.
T. Brauer, St. Petersburg.

3155aa. Bronze Compass taken from a wrecked Japanese junk. *Capt. Murray, per F. Buckland.*

3151d. Floating Mariner's Compass.
Dumoulin Froment, Paris.

3151e. Eclimétre for floating compass forming a spherical spirit level for quick elevation. *Dumoulin Froment, Paris.*

3151k. Dipping Needle and Compass used by Captain Cook during his voyage round the world.
Royal Naval Museum, Greenwich.

3151l. Chinese Compass, from a collection made by Mr. Coryton, Barrister-at-law of the Temple.
Royal Naval Museum, Greenwich.

3151m. Symon's True North Compasses, with improved indicator arranged to show the True North instead of the Magnetic North as usually shown. *L. Casella.*

3151n. Coloured Compass Cards. *Max. Raphael, Breslau.*

3151o. Mica-plates for uncoloured **Compass Cards.**
Max. Raphael, Breslau.

For the manufacture of compass cards, mica is now exclusively used. The advantage to be derived from its use consists in the greater facility with which the magnetic needle can be fixed, the transparency of the card, its non-conductivity for electricity, its lightness and indifference to ordinary changes of temperature, its durability, &c.

3151p. Compass, Hart's. *M. Bréguet, Paris.*

3151q. Patent True Course Finder. *W. H. Roberts.*

The object of this instrument is to avoid arithmetical calculation in finding the true course from the compass or magnetic course, with corrections for lee-way, deviation, and variation. This instrument will give by three movements of the index the true course to fifteen minutes. The outer rim of the dial is accurately divided into degrees, and the inner rim into points, ½ points, and ¼ points. The index has two arcs, A and B, and moves freely on a pivot, C. The arc A indicates the points, ½ points, and ¼ points. The arc B is so made that its centre line will point to the exact number of degrees which are contained in the number of points shown by the arc A. The arc B has also a vernier, by which the observer can read off to ¼ of a degree. On the extreme inner rim are arrows, half encircling the dial, to remind the observer in which direction to allow easterly and westerly deviation and variation.

3151r. Self-registering Ships' Compass, designed by J. M. Napier.—D. Napier and Sons, Vine Street, Lambeth.
South Kensington Museum.

3151s. Gimbal Compass, for use in small crafts.
South Kensington Museum.

3151x. Chinese Compass. *Ministry of Marine, Madrid.*

This differs from those employed by other nations, in the inversion of the meridian line.

3151y. Compass or Azimuthal Needle, which was employed in making the plans of the coast. This instrument was made at Carthagena, at the end of the last century.
Ministry of Marine, Madrid.

3151z. Compass made at Carthagena, Spain, according to the plan adopted by Don Antoino Doral, the Commander of Fleet. *Ministry of Marine, Madrid.*

V.—MAPS, BOOKS, &c.

COLLECTION OF MAPS, &c., LENT BY THE ORDNANCE SURVEY. MAJOR-GENERAL CAMERON, R.E., C.B., F.R.S., DIRECTOR-GENERAL.

Mounted Map of part of the city of Winchester, scale $\frac{1}{500}$, or 10·56 feet to one mile, with corresponding photographic reduction on $\frac{1}{2500}$ scale from MS. plan.

Mounted Map of part of London, scale 5 feet to one mile.

Mounted Map of Southampton and its environs, scale $\frac{1}{2500}$, or 25·344 inches to one mile.

Mounted Map of part of Hampshire around Southampton, scale 6 inches to one mile.

Mounted Map of part of Scotland (in outline), scale 1 inch to one mile.

Mounted Map of part of Scotland (hill features engraved), scale 1 inch to one mile.

Mounted Map of Jerusalem, showing the hill features, scale $\frac{1}{2500}$, or 25·344 inches to one mile.

Portfolio, containing specimens of Maps of Towns on the $\frac{1}{500}$ scale and 5 feet scale, viz. :—

$\frac{1}{500}$ scale, zincographed.

Cheshire, Chester, Sheets XXXVIII, 11, 17, 18; XXXVIII. 15, 2.

Cheshire, Hyde, Sheet XI, 1, 19.

„ Crewe, Sheet LVI, 7, 10.

Kent, Canterbury, Sheet XLVI, 3, 14.

Sussex, Chichester, Sheet LXI, 7, 16, 17, 21, 22.

Gloucester, Cirencester, Sheet LI, 10, 10. With shading of houses transferred to zinc from lines engraved on a copper plate.

Gloucester, Cirencester, Sheet LI, 11, 6. With shading of houses transferred to zinc from lines engraved on a copper plate.

5 feet scale, engraved.

London, Sheets VI, 30.

„ „ VII, 53, 56, 64, 65, 66, 73, 76, 77.

„ „ VIII, 12, 31, 41, 61, 71.

PORTFOLIO, containing specimens of MAPS of the CADASTRAL SURVEY on the $\frac{1}{2500}$ scale, or 25·344 inches to a mile, approximately 1 square inch to an acre, viz.:—

London, Sheets XLII, LXV, LXXIV, LXXV.
Denbigh, Llangollen, Sheet XXXIV, 15.
Cheshire, Chester, Sheet XXXVIII, 11.
Hants, Winchester, Sheet XLI, 13.
Kent, Canterbury, Sheet XLVI, 3.
„ Dover, Sheet XLVIII, 14.
Sussex, Rye, Sheet XLV, 7.
Forfar, Dundee, Sheet LIV, 5.
Lanark, Hamilton, Sheet XVII, 4.
Essex, Chigwell parish, Sheets LVII, 15 and 16; LVIII, 9, 13, 14; LXV, 3, 4, 7, 8; LXVI, 1, 2, 5, 6.
One book of areas of Chigwell parish.

Sheets of London reduced by photography from the 5 feet scale to the $\frac{1}{2500}$ scale, or 25·344 inches to one mile.

Sheets VII, 3, 13, 14, 23, 24, 73, 83, 93.

Photographic reduction used in producing the Cadastral Map on the $\frac{1}{2500}$ scale from the Town Map on the $\frac{1}{500}$ scale.

Sheets LXI, 7, 6, 7, 11, 12, 16, 17, city of Chichester.

PORTFOLIO containing specimens of COUNTY MAPS on the scale of 6 inches to one mile, viz.:—

Hants, Sheet XLI, LXV.
Kent, Sheets VII, XLII.
Middlesex, Sheets VII, XI, XVI, XXI.
Surrey, Sheets VII, VIII, XIV, XXIII, XXIV, XXV.
Aberdeen, Sheet LXXV.
Argyll, Sheets XCVIII, CXLIX, CLXXIX, CXC.
Bute, Sheet CCIV.
Dublin, Sheet XVIII.

Surrey, Sheet XVI. Reduced by photography from the $\frac{1}{2500}$ scale to the 6-inch scale and photo-zincographed.

Hampshire, Sheet LXXII. With a reduction to the 3-inch scale by photo-zincography.

Hampshire, Sheet LXXX. With a reduction to the 3-inch scale by photo-zincography.

12 mounted photographs reduced from MSS. plans on the $\frac{1}{2500}$ scale, or 25·354 inches to one mile, to the $\frac{1}{10560}$ scale, or 6 inches to one mile, by photography.

Photographic reductions used in producing the County Map on the scale of 6 inches to a mile ($\frac{1}{10560}$) from the MSS. sheets of the Cadastral Map. Scale, 25·344 inches to a mile ($\frac{1}{2500}$), viz:—

Essex, Sheets XLV, 10, 12; LX, 5.
Hants, Sheet VIII, 8.
Shropshire, Sheet XIII, 2.
Sussex, Sheet XXI, 16.

Map of the Turco-Persian frontier; made by Russian and English officers in the years 1849 to 1855, on the scale of $\frac{1}{73050}$, and reduced to the scale of $\frac{1}{253440}$, or four English miles to 1 inch, at the Ordnance Survey Office, Southampton. Drawn on Sir Henry James's Rectangular Tangential Projection of the Sphere; and photo-zincographed at the Ordnance Survey Office, Southampton, 1873.

PORTFOLIO, containing specimens of MAPS on the 1-inch scale, viz.:—

Geological Survey. England, Sheets XCII, S.W.; XCVIII, S.E.; CV, S.W.

Geological Survey. Scotland, Sheets IX, XXXII, XXXIII.

General Maps:—

England.

Sheets CCLXX, CCLXXI, CCLXXII, CCLXXXV, CCC.
Sheet XCVIII, N.W., outline and hills, two sheets.
„ XCVIII, S.W., do.
„ XCII, N.W., do.
„ CII, S.E., do.
„ CII, S.W., do.
„ CIV, S.W., do.

Scotland.

Sheets IX, XIII, XXI, XXIII, outline and hills, two sheets of each.
„ LXII, LXIII, (in outline), showing the parallel roads of Glen Roy.

Ireland.

Sheets XXVIII, XXXVI, outline and hills, two sheets of each.
„ XXIV, showing hill features.

ORDNANCE SURVEY of JERUSALEM, bound in three volumes.

ORDNANCE SURVEY of SINAI, bound in five volumes.

FACSIMILES of NATIONAL MANUSCRIPTS made by photo-zincography at the Ordnance Survey Office, Southampton, viz.:—

Domesday Book (1084–6), two volumes.
Black Letter Prayer Book of 1636, one volume.
Extracts from Parker's Register, 1559, one volume.
National Manuscripts, England, four volumes.
Do. Scotland, two volumes.
Do. Ireland, two volumes.

SURVEY OF PALESTINE, EXECUTED FOR THE PALESTINE EXPLORATION FUND.

Country from the Mediterranean to the Jordan Valley, including the greater part of the Plain of Esdraelon. Area, 907 square miles. Scale, 1 inch to the mile, by Lieut. C. R. Conder, R.E.

Part of the Wilderness of Judea on the west of the Dead Sea, and the hill country west of Jericho (Kurn Sartabeh), by Lieut. C. R. Conder, R.E.

Special plans, comprising the Roman Amphitheatre at Beisan (Bethshan), Kasr el Hajlah a crusading ruin south of Jericho, Joshua's Tomb at Tibneh, the ruins of Cæsarea, and details of a Temple at Abu Amr, by Lieut. C. R. Conder, R.E.

Reconnaissance survey of the Sea of Galilee and vicinity, by Captain Anderson, R.E.

Details of temples, &c., in the neighbourhood of Mount Hermon, by Captain Warren, R.E.

Reconnaissance survey of the Jordan Valley and neighbourhood, by Captain Warren, R.E.

Maps exhibited by the Ordnance Survey Department of the Royal Prussian General Staff, Berlin.

3152. Map A. Copy of an Original Survey taken by means of Surveyor's Table. (Plane table sheet.)

Map B. 1. Nine surveyor's table sheets, north-west from Berlin, original survey on the scale of $\frac{1}{25000}$ (2·534 inches to 1 mile), lithographed, with mountain features, marked in lines.

Map B. 2. The same district, scale $\frac{1}{50000}$ (2·534 inches to 1 mile).

Map B. 3. The same district, copper plate, scale $\frac{1}{100000}$ (0·634 inch to 1 mile).

Map C. 1. Eastern Prussia composed of the sections of the Ordnance Map of the General Staff, copper plate print, in $\frac{1}{100000}$, northern part.

Map C. 2. The same province, southern part.

Map D. The western part of the province Hesse-Nassau, copper plate, scale $\frac{1}{100000}$ (0·634 inch to 1 mile).

Map E. Environs of Berlin, copper plate print, scale $\frac{1}{100000}$, with watercourses, meadows, and villages, indicated by special colouring.

The maps A, B1, B2, B3, represent the process from the fieldwork to the publication of the maps on three different scales, namely, $\frac{1}{25000}$ (original survey); $\frac{1}{50000}$, and $\frac{1}{100000}$. The last is specially intended for military purposes.

The maps C1, C2, and D, show larger surfaces, the two former in hilly, the latter in mountainous country. On copper on the scale of $\frac{1}{100000}$.

The map E represents a surface of 70 geographical square miles in level country. On copper to the scale of $\frac{1}{100000}$, with the water, meadows, and districts coloured.

SECRETARY OF STATE FOR INDIA.

3153. Selection of Maps to illustrate the progress of **Cartography and Surveys in India.**

The Secretary of State for India.

(1.) Fortelezas de Mombaim e Ilha de Carania.

Old Portuguese plans of Bombay and Karanja, extracted from the "Livro de Antonio Bocarro, Guardamor de Archivo Real da India," &c., 1646. (Bombay was ceded to England in 1661, and became the seat of the presidency in 1683. The Portuguese retained the Island of Karanja in the harbour of Bombay until it was seized by the Mahrattas in 1683. In 1774 Karanja was taken by the English.)

(2.) Dutch chart of the Deccan (properly Concan) and Malabar Coasts, with the Laccadive and Maldive Islands and the Padua Bank, &c., including the western coast of India from Diu to Cape Comorin and part of the Gulf of Manaar, with soundings. Date, 18th century. MS. (No. 227).

Dutch chart of the Malabar Coast and Backwaters, from Coilang (Quilon) to Cranganor, with soundings. By Jan Tim, revised by H. G. Farrant, Engineer. Date, 1697. MS. (No. 229).

Dutch chart of the coast of Coromandel, from Tondy to Point Goddewarre (Godavery). Also a chart of the coast of Orissa. MS. (No. 254).

These are selected from a series of MSS., the originals of which are in the State Archives at the Hague, and catalogued in the "Inventaris der Verzameling Karten berustende in het Rijks Archief," 2 vols., 8vo.

(3.) Collection of Dalrymple's charts in 1 vol.

(4.) Bengal atlas, containing maps of the theatre of war and commerce on that side Hindoostan, compiled from the original surveys, and published by order of the Honourable the Court of Directors for the affairs of the East Indian Company, by James Rennell, F.R.S., late Major of Engineers and Surveyor-General in Bengal, 1781. (Second edition.) 21 maps, folio, bound.

(5.) Rennell's map of India.

(6.) Geographical and statistical map of the north-east part of the Mysore dominion or the ceded districts, &c. By Colin Mackenzie, Surveyor-General of India, 1815. Scale, 4 miles to 1 inch; size, 59 inches by 74. MS.

(7.) Topographical survey of Madras and its environs, by the Officers of the senior class of the Military Institution, 1806. Scale, 2 inches to 1 mile; size, 78 inches by 49. MS.

(8.) Mullangoor Circar, surveyed in 1834, on 15 small sections. MS.

(9.) Map of Mullangoor Circar, executed under the superintendence of Lieut. H. Du Vernet in the year 1834. Lithographed by Trel. Saunders.

(10.) Survey of the River Ganges from Hurdwar to Nahgul, taken in the month of February 1800, under the immediate instructions of Major-General Sir James H. Craig, K.B., &c. By Lieut. Thomas Wood, Corps of Engineers. Part 1. Size, 51 inches by 21. MS.

The survey is complete in 7 parts.

(11.) Survey to Gangotri, by Lieut. Webb, 1810. The general map scale, 24 miles to 1 inch. MS.

The survey on the scale of 1 inch to 1 mile is on 12 sheets.

(12.) . . . . Map of India, compiled from all the latest and most authentic materials . . . . By A. Arrowsmith. London, 1816.

(13.) Atlas of Southern India, in 18 sheets, from Cape Comorin to the river Kistnah, delineated on a scale of 4 English miles to 1 inch, principally from original surveys communicated by the Honourable Court of Directors of the East Indian Company. By A. Arrowsmith. London, 1822. Folio, half-bound.

(14.) The Indian atlas. The index map and sheets of the Punjab, mounted on roller.

(15.) Chart of the Red Sea, on three sheets. By Captain Moresby.

(16.) Atlas of the North-Western Provinces. Settlement maps compiled and lithographed under the order of H. M. Elliott, Esq., 1840 to 1843. Folio, half-bound.

Atlas of the district maps of the Lower and North-Western Provinces of Bengal, including the second edition of the district maps of the North-Western Provinces. Folio, 2 vols., half-bound.

(17.) Map of the Eastern Frontier of British India, with the adjacent countries extending to Yunan in China. By Captain R. Boileau Pemberton, 44th Regiment Native Infantry, 1838.

(18.) The districts Jhelum, Rawalpindi, and Shahpoor. By Captain D. G. Robinson, Engineers.

A specimen of the drawings.

(19.) The same lithographed on 28 sheets.

(20.) Map of Kashmir, with part of adjacent mountains. By Captain T. G. Montgomerie, Engineers, &c. Scale, 2 miles to 1 inch. On four sheets.

Jamoo, Kashmir, &c. Scale, 4 miles to 1 inch. On four sheets.

(21.) Madras revenue survey :—
 Nellore district map.
 Bapatla Taluk map.
 Kelampakkam village map.

(22.) Revenue surveys :—
 District Peshawur, 10 sheets.
 Peshawur Cantonment City, &c., four sheets.
 District Seebsaugur, Assam, 11 sheets.
 Topographical surveys :—
  Rewah survey, a selection mounted.

(23, 24.) General map of the Punjab, four sheets.
General map of the North-West Provinces, four sheets.
General map of Assam.

(25.) S. G. O. engravings of Indian atlas.

(26.) Himalayan sheets of Indian atlas.

(27.) Kumaon and Gurwhal, on 37 sheets, a selection mounted together.

(28.) Kattywar survey, a selection mounted together.

(29.) Guzerat survey, the three published sheets.

(30.) Colonel Walker's map of Turkistan, four sheets, mounted together.

(31.) Colonel Montgomerie's Trans-frontier maps.

(32.) Sholapore Collectorate, in a cover.

(33.) Laughton's Bombay, 172 sheets, a selection mounted together.

(34.) Ditto, reduced scale.

(35.) Native explorer's maps of—
 Arun River.
 Tengri Nor.
 Western Nepal.
 Rudok.
 Sanpu River.

(36.) The Mesopotamian surveys.

(37.) St. John's Persia, six sheets. Beluchistan.

(38.) Prinsep. Atlas of Sealkote district.

(39.) Progress Report maps.

(40.) Greenough's geological map of India.

(41.) Geological atlas of India.

3153a. Selection of Maps and Publications to illustrate the progress of **Cartography and Surveys in Spain.**

Istituto Geografico y Estatistico de Espana.

(1.) Red Geodesica de Primer Orden en 1874.

The actual state of geodetic studies in Spain is represented on a scale of $\frac{1}{20000000}$. The thick black lines mark the triangles in the French and Portuguese network, which is joined to the Spanish; thinner black lines mark the direction of the Spanish system; the black lines of the plan point out the quadrilateral directions or capitals of provinces. The localities of which the latitudes are determined astronomically are marked with a blue semicircle; the localities in which the difference of longitudes is determined are marked with a red semicircle; the azimuths known are marked with a blue circumference. The lines of levelling are traced with red ink, those already carried out with a continued line, and those not yet carried out by dots. The localities in which bench marks have been established are marked with a red cross.

(2.) Publications relating to the International Commission on the Metre.

The determination of the metre and international kilogramme is one of the most interesting problems of measurement.

The International Commission assembled to determine this was formed of members of all nations.

In the sessions held at Paris in 1872 this Committee removed all the general doubts relating to the construction and comparison of the international prototypes of weights and measures, and appointed a permanent committee instructed to carry on the work. The Spanish commissioner, Brigadier Ibañer, was named president.

The permanent Commission have spared no efforts to overcome the numerous difficulties presented in the construction of the metre and kilogramme and in the comparison of the metre of the French Archives.

They have completed the construction of two provisional bars for the metre, and they are now proceeding to melt the irridiated platinum for the metres required.

In the third pamphlet a description is given of the latest experiments.

(3.) Numerical Results of the Levels of Precision taken between Alicante and Madrid, and between Madrid and Santander.

The results given are those which have been obtained in the two levelling lines, giving the heights found in all the points of reference and the errors which appear.

(4.) Memoir upon the general compensation of the errors contained in the geodetic network of Spain, by Don Toaquin Barraquer and Don Francisco Cabello, Madrid, 1874.

This memoir is a most important study of geodesy, applied to the network formed by geodetic lines of the first order, which, following the direction of the meridians, parallels, and coasts, comprehends the Spanish territory of the Peninsula.

(5.) Studies of Geodetic Levelling, by Don Carlos Ibañer, 1 vol., 4to., pl., Madrid, 1864.

The object of the author is to examine the accuracy of the different methods employed up to the present time in geodetic studies to determine the third co-ordinate of the zenith of triangulations, and most especially to apply the practice of geodetic levelling to a theory presented 25 years ago by Biot, which had never been tried in Spain or elsewhere.

(6.) Instructions for Geodetic Studies. 1 vol., 8vo., pl., Madrid, 1872.

This book contains instructions for the observation of angles and the calculations necessary in geodetic triangles, and general instructions for the persons appointed to carry out the work.

(7.) Comparison of the Geodetic Standard Bar belonging to the Government of the Viceroy of Egypt with the one which served to measure the central base of the Map of Spain, by Ismail Effendi and Don Carlos Ibañer.

M. Brunner constructed, by order of the Egyptian Government, a base-measuring apparatus, identical in character with the Spanish pattern; he tested it in Paris in order to ascertain its co-efficient of expansion. It was, however, indispensable to determine its length, and to do so the Spanish geodetic bar was chosen.

Ismail Effendi came to Madrid with the Cairo astronomical apparatus; Don Ibañer was appointed for this commission; they both agreed as to the manner of conducting the operation, and they carried out the observations and calculations until they obtained the equation of the Egyptian bar with a probable error of $\pm 0 \cdot 0011^{\mathrm{mm}}$.

A full account of this is given in the book exhibited; the plate represents the comparator mounted at the Observatory of Madrid, to verify the comparison of the Egyptian and Spanish bars.

(8.) Plan of Madrid on a scale of $\frac{1}{2000}$.

This plan consists of several lithographed sheets, and includes all the details of the capital of Spain, the houses, number of streets, the trees, public and private gardens, and principal buildings.

The sheets are divided into squares, with their corresponding letter and number.

The levels are given by contours, traced at metre distances with the corresponding enumeration of the heights referred to the Mediterranean.

(9.) Memoirs of the Geographical and Statistical Institute of Madrid.

This important work comprehends the result of the geodetic studies between Salamanca and Madrid, terminated as far as the establishment of the interdepending equations between the calculations of every station and those that are required for the compensation of the whole polygonal system, the observations taken at every station, an account of these, the calculations of the most probable directions relating to every isolated station by the establishment of the equations already alluded to, &c.

The second memoir gives an account of the levelling of the line from Alicante to Madrid.

The third memoir describes the determination of latitudes and azimuths, and comprehends the astronomical geodetic studies carried out by the members of the Madrid Observatory for the Geographical Institute, in order to ascertain with proper exactitude the latitudes, longitudes, and azimuths, of a certain number of trigonometrical points of the first order. These studies were carried out by Don Manuel Morino.

The volume contains other papers of high topographical interest.

(10.) Topographical Map of Spain.

The map of Spain on a scale of $\frac{1}{50000}$ is composed of about 1,078 sheets, engraved in five colours, with numerous details. The sheets comprising Madrid, Colmenar, Viejo, and Yetafe are already engraved.

The general plan of the levellings projected for Spain (plate 20) comprehend, besides the line of Alicante to Santander, passing by Madrid, other lines which, starting from Madrid run one to the N.E. which is to connect itself in Perpignan with the French lines, another towards the south, which will serve to determine the difference of levels between the observatories of Madrid and St. Ferdinand, and two others which starting from Madrid will go to Lisbon and Oporto. The remaining lines will complete this plan, and bring out the levels of the capitals of provinces and towns of importance.

The system of lines is so disposed that it offers numerous polygons in order to establish conditions which may give greater precision to the results.

In conformity with the instructions of the Commission appointed to carry out this map, the levelling of precision will follow in general the lines of communication, such as railroads and bye-roads of every description. The levelling will be duplicate, and carried out from the centre by different observers, and with different instruments. The calculations will be taken from Madrid. The greatest error admissible, deduced from a double levelling, is not to exceed 4 millimeters per kilometer, and in general will be less than $5^{mm}\sqrt{R}$, R being the number of kilometers.

The general lines will be divided into independent sections, and these into portions of a kilometer, with benchmarks at the extremities of the section, important towns, &c.

In August 1871, the levelling of the line between Alicante and Madrid was begun; touching Madridejos at its base, 540 kilometers were levelled in 916 days, of which only 451 were useful. The number of stations verified was 11,782.

The line from Santander to Madrid was levelled in 1873 in the same manner, and this will determine the difference of level between the ocean and Mediterranean.

Without taking into account the datum points of the seaport towns, a standard datum has been established irrespective of mean sea level. This point is situated at the observatory of Madrid, although, considering its geological conditions, the hill upon which it is placed does not offer the securities which might be desired. Four others have been placed in different parts of Madrid.

(11.) Experiments made with the Base-measuring Apparatus belonging to the Commission of the Map of Spain. Madrid, 1859.

The authors, Don Carlos Ibañer and Don Frutos Saavedra Meneses, were appointed in 1853 to design the system of microscopes and bars with which the base of the geodetic network of the Peninsula was to be measured. They went to Paris to superintend the construction of an apparatus of their invention, intrusted to M. Brunner.

This apparatus principally consists of a platinum bar, which forms a metallic thermometer with another of latteen; they both rest on an iron bench placed upon movable supports resting upon wooden tripods. Various micrometer microscopes are placed in the centres of graduated circles fixed in other tripods, and these divide the base which is to be measured into small intervals, the lengths of which are determined by placing the bar between every two microscopes, and observing the divisions on the platinum and latteen. An eyepiece and two lenses are used to range the tripods of the microscopes in the line of the base, and another glass settles the beginning and end of the day's work.

This delicate apparatus cannot be sent out of the country; it is preserved at the Geographical Institute of Madrid.

After this study was made, the expansion of the bars was investigated and compared with that of Borda, at the Paris Observatory, which has served as the standard of all the geodetic bases measured in France since 1798.

The result of the studies is given in this work, and the manner of using this apparatus and carrying out the calculations.

These plates represent—

(*a.*) Two of the projections of the bar and level mounted upon its supports and tripods, and the microscopes placed to observe the lines of division at the extremities.

(*b.*) Details of the construction of the supports of the bar, the slow and quick movements which it is capable of making, the construction of the latteen and platinum bars, the details of the same divided into decimilimeters, and a drawing of the level of the bar.

(*c.*) Details of the micrometer microscopes, circles, reference glass, lenses, and tracers.

(*d.*) The comparator. Experiments to verify the studies of expansion in oil bath.

(*e.*) Same in detail as the former.

(*f.*) Apparatus used by the observers in the construction and comparison of thermometers.

(*g.*) Borda's bar with which the Spanish one was compared.

(12.) Geodetical description of the Balearic Islands, by Don Carlos Ibañer. Madrid, 1871.

The author was commissioned in 1864 to study the first of the geodetic Catastralian districts, which are comprehended in the provinces of Castellon, Valencia, Alicante, and Balearic Islands; he verified it in the campaigns of 1865, 1866, 1867, and 1868, and made the necessary studies to describe and interlace the three groups formed by the islands of Tviza and Formentera with surrounding islets, with those of Mallorca, Cabrera, and Dragonera, and with the island of Minorca and adjacent islets. Each of these groups with its corresponding triangulations is divided by first, second, and third class nets.

Each local triangulation was founded upon a base measured by the Ibañer apparatus, constructed by Messrs. Brunner.

In the first part of this work will be found a description of the instruments and accessories employed in this study, beginning with the new apparatus for measuring bases. This consists principally of a plated iron bar, with four thermometers of mercury and a plane table, placed upon tripods and supports, microscopes, and lineation glasses, and reference to the beginning and end of the daily work. This apparatus offers the greatest advantage over other analogous instruments, for the rapidity and ease with which the measures are taken, without losing the degree of exactitude required for a geodetic base. It is to be employed to measure the three bases still wanting in the Spanish geodetic net projected in the provinces of Cadiz and Lugo.

The probable errors resulting from the measurement of the Balearic Islands were—

Base of Ibiya $\pm 0{\cdot}401^{mm}$, or $\pm 0{\cdot}00000240$ of the length measured.

Base of Prat, Mallorca, $\pm 1{\cdot}681^{mm}$, or $\pm 0{\cdot}000000794$ of the measured length.

Base of Mahon (Minorca) $\pm 0{\cdot}770^{mm}$, or $\pm 0{\cdot}000000326$ of the length measured.

The Southampton Institute has made several metrological studies. The apparatus designed by Ibañer, which was connected with the bar constructed by Borda, produced the most satisfactory results.

The three other parts of this work refer to triangulations of the three groups of the above-mentioned islands. The plates represent—

(*a.*) The bar of the Ibañer apparatus in two projections, mounted for observation.

(*b.*) Details relating to the supports of the bar and its construction.

(*c.*) Microscopes; glasses and other details of this apparatus.

(*d.*) Form, dimensions, and construction of the station marks established at the trigonometrical points of the 1st, 2nd, and 3rd order.

(*e.*) The theodolites employed for the azimuth and zenith observations in 1st class triangles of the Balearic Islands.

(*f.*) Theodolite of 2nd class.

(*g.*) Geodetic local networks interlacing the groups of the Balearic Islands. Printed in three colours. The first class network is in black, the 2nd in red, the 3rd in blue.

(13.) Central base for Geodetic Triangulation in Spain, by Don Carlos Ibañer, Lieut.-Col., &c., Don Frutos Saavidra, Don Fernando Monet, and Don Cesario Quiroga; Madrid, 1865.

The parting line chosen for the geodetic triangulation of Spain starts from the central base of Madridejos (province of Toledo). The direct measurement gave a result of 14,664$^{\text{m}}$, $\pm 0{\cdot}0025^{\text{m}}$, with a difference of level between the extremes (Bolos y Carbonera) of $2{\cdot}482 \pm 0{\cdot}010^{\text{m}}$.

These studies were carried out by the observers mentioned on the title-page of the book, by means of the apparatus of Ibañer.

The measurements adopted to fix the extremities of the base, and establish a trigonometrical network by which it might be determined whether it was necessary or not to measure bases of great extent, are all given in detail in this work. The observations and calculations for the measurement and levelling of the base, the triangulating studies and compensation of the network, and the final results of this operation are also mentioned.

The results of these operations, and their precision, may be judged by the probable error of measurement, which has already been mentioned, as $\pm 0{\cdot}0025^{\text{m}}$, or $\frac{1}{5800000}$ of the length of the base.

In order to decide the question of the extent of base line requisite, a comparison was made between the direct measurement of the sections of the base and their length deduced from the calculations of the trigonometrical network, which gave the following results:—

——	Measure.	Triangulation.	Difference.
	m	m	
First section - -	3077·459	3077·462	−0·003
Second „ - -	2216·397	2216·399	−0·002
Third „ - -	2766·604	2216·399	−0·002
Fourth „ - -	2723·425	2723·422	+0·003
Fifth „ - -	3879·000	3879·002	−0·002
Base - - -	14662·885	14662·889	−0·004

These remarkable results proving the direct measurement, at the same time give authority for reducing the length of the geodetic base to two or three kilometres, that is, whenever they are connected with the sides of the net by means of a system of lines suitable for compensation. This is the first experimental result of the kind given in geodesy.

PLATES.

(*a.*) Measurement of Madridejos wooden gallery formed of nine moveable houses in which the apparatus was sheltered from sun and wind.

(*b.*) Plan on scale of $\frac{1}{50000}$ of the country surrounding the base Madridejos with division in sections.

(*c.*) Vertical sections of the central base, on a scale of $\frac{1}{20000}$, for horizontal distances, and $\frac{1}{1000}$ for the heights.

ADMIRALTY—HYDROGRAPHIC DEPARTMENT.

ORIGINAL (MS.) JOURNALS AND LOG BOOKS, &C. KEPT BY CELEBRATED ENGLISH NAVIGATORS BETWEEN THE YEARS 1768 AND 1825.

3154. Dampier's original MS. Chart of his voyage to New Guinea, 1699–70.

3155. Cook, Captain James. Journal of the proceedings of H.M. bark the "Endeavour," in a voyage round the world; performed in the years 1768–69–70–71. Folio.

3156. Cook, Captain James. Journal of the proceedings of H.M. sloop "Resolution," in exploring the South Atlantic, Indian, and Pacific Oceans, in the years 1772–73–74–75. Folio, with charts.

3157. Bligh, Captain William. Log of the proceedings of H.M. armed vessel "Bounty," in a voyage to the South Seas, to take the bread-fruit from the Society Islands to the West Indies, in the years 1787–88–89. Folio. Including an account of the mutiny.

3158. Bligh, Captain William. Log of the proceedings of H.M.S. "Providence," on a second voyage to the South Seas, in the years 1791–92–93. Folio. 2 vols.

3159. Franklin, Sir John. Log of the proceedings of H.M. hired brig "Trent," in a voyage towards the North Pole, in the year 1818. Folio.

3160. Parry, Sir Edward. Log of H.M.S. "Alexander," in a voyage for the discovery of a North-west passage, in the year 1818. Folio.

3161. Parry, Sir Edward. Official journal of H.M.S. "Hecla," in the years 1819–20. Folio. 3 vols.

3162. Parry, Sir Edward. Official journal of H.M.S. "Fury," in the years 1821–22–23. Folio. 2 vols.

3163. Parry, Sir Edward. Log of H.M.S. "Hecla," in the years 1824–25. Folio.

CHARTS AND PLANS.

3164. North Atlantic Ocean (Chart). Compiled in the Hydrographic Office of the Admiralty. Scale, 0·5 inches to a degree of longitude.

3165. British Islands (Chart). Compiled from the latest Admiralty Surveys. Scale, 1·4 inches to a degree of longitude.

3166. Lough Swilly, Ireland (Plan). Surveyed by Captain G. A. Bedford, R.N. Scale, 2·3 inches to a nautical mile.

3167. West Coast of Scotland (Chart). Compiled from the latest Admiralty Surveys. Scale, 5·3 inches to a degree of longitude.

3168. Davis Strait (Chart). Compiled from the latest Danish Government Charts; and information derived from British and American Exploring Expeditions. Scale, 0·9 inches to a degree of longitude.

3169. South Atlantic Ocean (Chart). Compiled in the Hydrographic Office of the Admiralty. Scale, 0·5 inches to a degree of longitude.

3170. Gulf of Suez (Chart). Surveyed by Captain G. S. Nares, R.N. Scale, 0·23 inches to a nautical mile.

3171. Port Royal and Kingstown Harbours, Jamaica (Plan). Surveyed by Staff-Commander George Stanley, R.N. Scale, 2·5 inches to a nautical mile.

3172. Indian and Western Pacific Oceans (Chart). Compiled in the Hydrographic Office of the Admiralty. Scale, 0·2 inches to a degree of longitude.

3173. Pacific Ocean, between the parallels of 37° N. and 37° S. (Chart in four sheets). Compiled in the Hydrographic Office of the Admiralty. Scale, 0·62 inches to a degree of longitude.

3173a. Port Simpson, British Columbia (Plan). Surveyed by Staff-Commander Daniel Pender, R.N. Scale, 3 in. to a nautical mile.

3174. Candia or Crete (Chart). Surveyed by Captain Thomas Spratt, R.N. Scale, 0·5 inches to a nautical mile.

3175. Spithead (Plan). Surveyed by Captain Sheringham and Staff-Commander Daniel Hall, R.N. Scale, 2·75 inches to a nautical mile.

3176. North Sea, Dover to Scheveningen (Chart). Compiled from the most recent British and Foreign Surveys. Scale, 0·3 inches to a nautical mile.

3177. Dover Strait (Chart). Compiled from the latest British and French Surveys. Scale, 0·7 inches to a nautical mile.

3178. Zanzibar Harbour, east coast of Africa (Plan). Surveyed by Commander W. J. L. Wharton, R.N. Scale, 1·5 inches to a nautical mile.

3178a. Mikindani Bay, East Coast of Africa (Plan). Surveyed by Lieut.-Commanding F. J. Gray, R.N. Scale, 2 inches to a nautical mile.

3179. Plymouth Sound and Hamoaze (Plan). Surveyed by Commander H. L. Cox, R.N. Scale, 6·0 inches to a nautical mile.

3180. Curves of equal Magnetic Variation, 1871. Compiled by Staff Captain F. J. Evans and Navigating Lieutenant E. W. Creak, R.N.

3181. Current Chart of the Pacific, Atlantic, and Indian Oceans. Compiled by Staff Captain F. J. Evans and Staff Commander Thomas A. Hull, R.N.

3182. Ice Chart of the Southern Hemisphere. Compiled by Staff Captain F. J. Evans and Staff Commander G. F. McDougall, R.N.

3183. Antarctic Charts lent by the Hydrographic Office.

S 91.	New South Britain (South Shetland Islands)	Captain Smith, 1819 (original drawing).
S 92.	South Shetland Islands.	Mr. Bransfield, 1820.
543.	Kerguelen Island.	Captain Cook, 1776–9 (original drawing).
445.	Do.	Captain Rhodes, 1799 (original drawing).
A 4323.	Do.	Compiled in Hydrographic Office, 1874.
A 3711.	Heard and McDonald Islands.	Captain Nares, 1874.
A 508.	Powell's group (South Orkneys).	Captain Powell, 1821–2.

L 1752. Louis Philippe Land. Captain Dumont D'Urville, 1838.
L 2115. Adelie Land and Côté Clarie. Do. 1840.
L 3125. Antarctic Continent. Lieutenant Wilkes, United States Navy, 1840. Auckland and Campbell Islands.
L 4589. Victoria Land. Captain James Clark Ross, 1841.

ATLASES.

3184. Atlantic Pilot Charts.

These charts show in a graphic form the prevailing winds and other phenomena for periods nearly corresponding to the seasons of the year. A general chart of the ocean currents is also given.

3185. Wind and Current Charts for the **Atlantic, Pacific,** and **Indian Oceans.**

To these are added smaller synoptical charts showing lines of equal air temperature, barometric pressure, and sea-surface temperature.

3186. Officers' Atlases, containing a selection from the Charts supplied for the navigation of Her Majesty's Ships.

3187. Index to the Charts and Plans published by the Hydrographic Office of the Admiralty.

3187a. Globe illustrative of the **Earth's Magnetism.**

3187b. Maps illustrative of the **Earth's Magnetism.**

ROYAL GEOGRAPHICAL SOCIETY OF LONDON.

3188. Collection of Arctic Charts.

3188a. Pictorial Diagrams of the Arctic Regions.

3188b. Pictorial Diagrams of the Aurora Borealis.

3189. Arctic Maps.

1. Facsimile of the ancient chart of the Zeni. (R.G.S.)*
2. The map of Hondius, from Pontanus. (H.S.)
3. Petermann's map, showing the track of Barents. (R.G.S.)
4. Gerrit de Veer's map of the voyage of Barents. (R.G.S.)
5. Map of Spitzbergen from Purchas. (G.M.)
6. Hudson's map of 1612. (H.S.)
7. Van Keulen's chart of Spitzbergen. (G.M.)
8. Dutch chart of Davis Strait after 1721 : translated into English. (A.)
9. Phipps's MS. chart of North Spitzbergen. (A.)
10. Circumpolar chart of 1818. (R.G.S.)
11. Chart of Baffin's Bay, by John Ross, 1818. (A.)
12. Buchan's voyage to Spitzbergen, with tracks. MS. by Beechy. (A.)

13. Chart of Parry's discoveries. First voyage. MS. by Liddon. (A.)
14. Parry's discoveries. First voyage. MS. by Bushnan. (A.)
15. Parry's discoveries. Second voyage. MS. by Bushnan. (A.)
16. North of Spitzbergen and Parry's track in 1827. MS. by Foster. (A.)
17. Graah's chart of Julianshaab, Greenland. (R.G.S.) Danish map of Greenland with Eskimo names. (R.G.S.) Moller's chart of Baal's river and the Godthaab district. (R.G.S.)
18. Circumpolar chart of 1835. (A.)
19. Circumpolar chart of 1838. (A.)
20. Simpson's chart from Point Barrow to Return Reef. (R.G.S.)
21. Facsimile of the chart supplied to Sir John Franklin. (R.G.S.)
22. Circumpolar chart of 1850. (R.G.S.)
23. Parry Islands and Arctic America, 1850. (A.)
24. Track of H.M.S. *Assistance* to the Cary Islands, 1851. (A.)
25. Sutherland's circumpolar physical map, 1851. (R.G.S.)
26. Charts by Arrowsmith of the coast of Arctic America, showing Dr. Rae's journeys. (S.)
27. Herald Island, MS. and views. (A.G.S.)
28. Chart of Baffin's Bay, with Capt. Inglefield's corrections. (A.)
29. Discoveries of M'Clure (4 sheets MS.) (A.)
30. Arrowsmith's chart showing the discoveries of M'Clintock in 1859. (R.G.S.)
31. M'Clintock's discoveries. MS. by Allen Young. (A.)
32. Circumpolar chart of 1859. (R.G.S.)
33. Admiralty chart of Kane's discoveries up Smith's Sound. (R.G.S.)
34. Kane's original MS. chart of his discoveries. (R.G.S.)
35. Petermann's map of Wrangell Land, 1869. (R.G.S.)
36. Captain Long's chart and sketch of Wrangell Land, 1867. (R.G.S.)
37. Swedish chart of Spitzbergen.
38. Petermann's map of Nordenskiold's voyage to Spitzbergen in 1868. (R.G.S.)
39. Petermann's map of the north end of Novaya Zemlya, 1872. (R.G.S.) Petermann's maps of Novaya Zemlya, Waigat Isles, Matotchin Shar, &c. (R.G.S.)
40. Track of Captain Koldewey's voyage in 1868, by Petermann. (R.G.S.)
41. Discoveries of the German expedition on the east coast of Greenland. (R.G.S.)
42. Franz Joseph Land. Discoveries of the Austrian expedition. (R.G.S.)
43. Map showing the "Hypothesis Petermann," & making Smith's Sound a *cul de sac*. (R.G.S.)
44. Polar discoveries of Hall in the *Polaris*, American chart. (R.G.S.)
45. Map showing the drift of the boat of the *Polaris* down Baffin's Bay, by Petermann. (R.G.S.)
46. Track of the *Arctic* in 1873, by Commander A. H. Markham, R.N. (G.M.)
47. Circumpolar chart by Stanford, 1875. (S.)
48. Track of the *Alert* across the Atlantic. (A.)
49. Disco Island. (G.M.)
50. Track of the *Alert* from Upernivik to the Cary Isles. (G.M.)
51. New chart of Baffin's Bay. (A.)
52. New chart of Smith'sSound. (A.)
53. New half circumpolar chart. (A.)
54. Chart showing winter quarters of all expeditions. (A.)
55. Projection for the use of the Arctic Expedition, 1875-6. (A.)

*REFERENCES:—(R.G.S.) From the collection of the Royal Geographical Society. (A.) From the Admiralty. (H.S.) From the Hakluyt Society's volumes. (G.M.) From the *Geographical Magazine*. (S.) From Mr. Stanford.

3189a. Four Views, Antarctic Regions.

3190. Manuscript Maps of Celebrated Explorers.

Year.	Title.	Name of Explorer.
1850	River Zambesi - -	Dr. Livingstone.
1853	River Leeba - - -	Dr. Livingstone.
1854	Victoria Falls to Loand -	Dr. Livingstone.
1854	River Coanza - - -	Dr. Livingstone.
1854	River Quango - -	Dr. Livingstone.
1855	Zanzibar to Uniamesi Sea -	Erhardt and Redmann.
1855	Loand to Victoria Falls -	Dr. Livingstone.
1855	Country South of Zambesi -	Dr. Livingstone.
1856	Victoria Falls to Tétè -	Dr. Livingstone.
1857	River Pangani - -	Burton and Speke.
1858	Khartum to Gondokoro -	J. Petherick.
1858	Zanzibar to Ujiji - -	Burton and Speke.
1858	Kasé to Lake Victoria -	Speke.
1859	Lake Shirwa - - -	Dr. Livingstone.
1860	Sources of the Nile - -	G. G. Miani.
1860	Zanzibar to Gondokoro -	Speke and Grant.
1861	Zanzibar to Gondokoro -	Speke and Grant.
1861	Lake Nyassa - - -	Dr. Livingstone.
1862	Khartum to Albert Nyanza -	Sir S. Baker.
1862	Lake Albert Nyanza - -	Sir S. Baker.
1862	Zanzibar to Gondokoro -	Speke.
1863	Sources of Nile - -	J. Petherick.
1868	Eastern Turkistan - -	G. H. Haywood.
1875	Lake Victoria - -	H. M. Stanley.

3190a. Diagram of Africa, showing Comr. V. L. Cameron's route across that Continent, also the general river basins and drainage.

3190b. Sectional Route, by Comr. V. L. Cameron, R.N., C.B.

3191. Specimens of Printed Maps in the Journal of the Society.

Glaciers of the Mustakh Range, India, by Capt. H. G. Austen.

Canterbury and Otago, New Zealand, Messrs. McKerron, Haast, and Hector.

Vancouver Island, Dr. C. Forbes, R.N.

Small portrait (1 foot square) of Dr. Livingstone, considered the best likeness.

3192. Model of the Victoria Falls, River Zambesi. By T. Baines, Esq., F.R.G.S.

3193. Views. Descriptive Geography.

12 Water-coloured views of glaciers, Middle Island, New Zealand.

10 views of the Victoria Falls, Zambesi River, by T. Baines, Esq.

3 views in Eastern Turkistan, near Kashgar, &c., by G. H. Haywood.

Sketches of the natives, Island of Formosa, with map. Exhibited by Admiral Sir R. Collinson, K.C.B.

3194. Photographs taken in China. Four volumes. By J. Thomson (Paris Medallist).

3195. 21 Views on the River Zambesi (oil paintings), by the late T. Baines, F.R.G.S.

3196. Collection of Publications of the Society.

A complete set of the Journals, 45 vols.
Arctic papers for the Expedition of 1875.
The lands of Cazembe, Lacerda's journey, &c.
Hints for Travellers.
A complete set of the "Proceedings," 19 vols.

3197. Geographical Diagrams (Wall Maps).

1. Smith's Sound.
2. Central America.
3. Vancouver's Island and British Columbia.
4. Abyssinia.
5. Mount Sinai.
6. Korea and Eastern China.
7. Pigafetta's Congo (Ancient Africa).
8. Caucasus.
9. Zeno's Map.
10. Spitzbergen.
11. South-west Pacific, Fiji Islands, &c.
12. Burma.

3198. Pictorial Diagrams (Geographical).

1. View of the volcano of Santorin, large.
2. ,, ,, small.
3. Crater of Kilauea, Sandwich Islands.
4. Murchison Falls (River Nile).
5. View in Fiji Islands.
6. ,, ,,
7. Ruined Esquimaux hut.
8. Aurora Borealis (five diagrams).
9. Section of an ice-blink or glacier.

3199. Ancient Maps of the **Sources** of the **Nile.**

1.	1508 - - -	By Ptolemy.
2.	1550 - - -	Sebn. Munster.
3.	15th century - -	?
4.	1618 - - -	?

3199a. Map, showing the principal **Caravan Routes** of Eastern commerce, ancient and modern. By Dr. Yeats, F.R.G.S.

3200. Miscellaneous Contributions by the **Geographical Society.**

Three cases of select specimens of Cartography (105 in No.).
Educational models, various.
Engraved Portraits of celebrated explorers.
Barent's relics, 1597; water-coloured drawing.
Pizigani's Map of the World, 1367.

MAPS, GLOBES, AND MISCELLANEOUS OBJECTS BY VARIOUS CONTRIBUTORS.

3201. Models to illustrate the arts of Camp Life.
Francis Galton, F.R.S.

This case of models and specimens was made at the same time as 10 others that were constructed in 1858, by order of the War Office, after the design of a set which Mr. Galton caused to be made, and had presented to the Royal Institution at Woolwich in the previous year. Their object was not only to interest and instruct individual soldiers, but rather to suggest to instructors the precise subjects on which practical classes in the arts of camp life may most usefully be engaged. A catalogue accompanies the case in which the models are contained, and in this an asterisk is placed opposite to those objects which Mr. Galton's experience leads him to prefer for the purpose. "An old campaigner's acquirements consist partly in knowledge and partly in handiness. "Field lectures, illustrated by experiments, may convey the first to an "intelligent novice, and it was hoped that these models might serve to "explain what kind of things must be made by his hands, before he can "acquire the latter."

The examples illustrate the various modes of the production of fire, the procuring, purifying, and carriage of water, cooking, the uses of portable food, substitutes for boats, cattle enclosures, expedients for tools and appliances in various handicrafts, tenting, hutting, and various other needs of camp life.

3202. Stereoscopic Maps, taken photographically, from models in relief. *Francis Galton, F.R.S.*

A much clearer notion of the physical features of a country may be obtained from a model in relief than from an ordinary map, however carefully executed, but the great weight and cumbrousness of models makes them unsuitable for the library or for travel. The chief advantages of both methods of illustration may in great measure be secured by stereoscopic maps taken photographically from models. The accompanying specimens were exhibited in illustration of a memoir read before the Royal Geographical Society in 1865, a copy of which is placed beside the photographs. It is there shown that the proposed plan has two other unexpected advantages. First, owing to causes there explained, we are able to deal with models of considerable dimensions both laterally and longitudinally, for when such a model has been photographed stereoscopically in separate squares, and the prints have been properly united, it becomes possible to view any part of the map with pseudo-stereoscopic if not with stereoscopic effect. Secondly, it is shown, that the insertion of names improves the appearance of relief in models, and consequently in the stereoscopic representations of them, while it spoils the effect of shading in ordinary maps.

3176a. Maps of the Baltic, Western Part, compiled from the surveys of the Imperial Admiralty, and published by the Hydrographic Office of the Admiralty.
Hydrographieal Department of the Imperial Admiralty, Berlin.

This is a sheet from a series of charts of the littorals of the Baltic, which it is proposed to publish in the course of the next few years, and may thus serve as an example of the scale on which the work will be done.

3202c. Perspective Map of Africa, according to French, English, and German travellers.
M. Launay, Professor at the Lyceum of Caen.

This map was executed previously to the publication of the accounts of Mr. Stanley, respecting Lake Ukériné, of Comr. Cameron respecting Lake Tanganiyka, and of M. Grandidier respecting Madagascar.

3203. Map of **Gaul,** showing by different coloured tracings the relative antiquity and importance of the Roman roads.

M. Hayaux du Tilly, Paris.

3203a. Old Spanish Map of the Province of Aragon, &c., with the roads, bridges, hill-shading, &c., inserted in MS. by Captain H. Bristow, by means of the pocket-sextant, No. 3107j.

H. W. Bristow, F.R.S.

During the Peninsular War, great difficulty was experienced in getting accurate maps of Spain for the British army.

The most accurate Spanish maps then procurable were old, very defective, and nearly useless as route maps, owing to the roads, hill-shading, &c. not being shown upon them. These details had to be supplied for the use of the army by the officers attached to the Quartermaster-General's department, the engraved maps serving as the groundwork for the new survey.

The old Spanish map of the province of Aragon and surrounding districts is one of those maps upon which the roads, bridges, the defences of Saragossa, and other details, were so supplied in MS. by Captain Bristow, by means of the pocket-sextant, No. 3107j.

3203b. Collection of Water-colour Sketches of the glaciers of the **Mustak Range,** Little Thibet, &c.

Major Goodwin Austen.

3203c. Map of the Great Glaciers on the North of the Swiss Alps; with index card.

Prof. Alphonse Favre, Professor of Geology at the Academy of Geneva.

3203d. General Map of Ireland, on roller.

General Valuation of Ireland, Dublin.

3203e. Model of Victoria: 70″ × 50″.

The Agent General of Victoria.

3203f. Map of Victoria: 38″ × 26″.

Sketch of new geological map of Victoria: 38″ × 26″.

The Agent General of Victoria.

3204a. Specimen Sheets of the two most important Productions of the Topographical Department at St. Petersburg. Copper plate.

The Topographical Department of the Imperial Russian General Staff, St. Petersburg.

1. Topographical map of the western part of European Russia in 507 sheets. Scale, 1:126,000.

2. Special map of European Russia in 145 sheets. Scale, 1:420,000.
   - *a.* Copies from copper plate in two colours.
   - *b.* Transfer print from lithographic stone, and chromo-lithography in four colours, black for the skeleton and the writing; brown for the ground of the country; blue for the watercourses, and green for forests and woods.

3204b. Map of Trans-Caspia, in five sheets. Scale 1:840,000. Lithographed in Tiflis.

The Topographical Department of the Imperial Russian General Staff, Tiflis.

The dry bed of the Amu-Darja has been indicated on the map according to the latest survey.

3205. Map of the Hop-growing Districts of Central Europe, by Joh. Carl, editor of the General Hop Gazette, and C. Homann, containing:—

1. Agrarian statistical general map of the European hop-growing districts on the Continent and in England.
2. Special map of Bavaria.
3. ,, Bohemia.
4. ,, Wurtemberg and Baden.
5. ,, Belgium.
6. Tabular and graphical representations of the cultivation of hops, and of the hop consumption of the whole world.
7. Classification of the various sorts of hops.
8. Comparative tables of the agrarian measures and commercial weights. *J. Carl and C. Homann, Nüremberg.*

The maps represent the cultivation of hops in a manner not to be found elsewhere. The agrarian statistical general map shows the hop cultivation of the Continent and England, and contains special maps of the principal hop-districts of England, Bavaria, Bohemia, Württemburg, Baden, Belgium, &c. The tabular and graphical representations contain very important statistics as to the cultivation, production, and consumption of the whole world, which may be summed up as follows:—

—	Surface under Cultivation.	Production.	Consumption.	Production + or − Consumption.
	hectares.	cwts.	cwts.	cwts.
Germany - - -	37,910	477,111	321,500	+155,611
England - - -	25,696	384,090	600,000	−215,910
Austria - - -	7,711	92,532	100,000	− 7,468
Belgium - - -	6,500	97,500	15,000	+ 82,500
France - - -	4,000	48,000	48,000	—
The rest of Europe - -	619	8,454	25,500	− 16,546
Total Europe - -	82,346	1,107,687	1,109,500	− 1,813

The produce and surface under cultivation of the hop districts of the different countries are also shown in the same way. The average production of one hectare in an average crop is as follows:—

In Prussia	per hectare	12	cwts.,	in all	59,400	cwts.
,, Bavaria	,,	12	,,	,,	212,556	,,
,, Württemburg	,,	15	,,	,,	73,595	,,
,, Baden	,,	15	,,	,,	26,310	,,
,, Alsace and Lorraine		12	,,	,,	9,000	,,
,, the rest of Germany		12–15		,,	15,150	,,
Total produce of an average crop in Germany					396,011	,,

The most noted hop districts are all indicated by the colouring; the principal localities of production are also indicated.

3206. Wetzel's Wall Map of Mathematical Geography. *Dietrich Reimer, Berlin (Reimer and Hoefer).*

3207. Kiepert's Physical Wall Maps, &c., viz.:—

Wall map of the Eastern Planiglobe.
Wall map of the Western Planiglobe.
Wall map of Palestine. Scale, 1 : 200,000.
Wall map of Palestine. Scale, 1 : 300,000.
Map of Europe.
Map of Asia.
Map of Africa.
Map of North America.
Map of South America.
Map of Australia.
Small hand atlas.
Small school atlas.
Adami-Kiehert's school atlas.

Dietrich Reimer, Berlin (Reimer and Hoefer).

3207a. Physical Map of the Colony of Natal, showing the central highlands, the northern one-river basin, and the southern many-river system of watersheds. *Dr. Mann.*

The central highlands are shown to be a spur from the inland mountain frontier, or Drakenberg range, with finger-like subdivisions descending to the coast to constitute the many-river system which is developed there.

3208. Möhl's Orohydrographical Wall Map of Germany. *Th. Fischer, Cassel.*

3209. Map of **Hesse-Nassau.** *Th. Fischer, Cassel.*

3210. Map of **South-western Germany.** *Th. Fischer, Cassel.*

These maps, Nos. 3208, 3209, 3210, are lithographed in the exhibitor's offices after a method of representing the earth's surface, first published by Professor Möhl. The printing is effected by scraped and chalk stones, besides the ordinary colour stones.

3211. Carta geografica de la Républica de Costa Rica (Central America). Scale, 1 : 500,000. Constructed by L. Friederichsen, 1876. *L. Friederichsen and Co., Hamburg.*

This map has been drawn and produced, on the foundation of important original materials, by L. Friederichsen, under the authority of the Government of Costa Rica. It shows for the first time the geography of the Republic of Costa Rica on a large scale.

3213a. Map of the Central Part of the Chain of the Caucasus; scale, $\frac{1}{565000}$. *M. Ernest Favre, Geneva.*

Geological map of the central part of the Caucasus, executed by M. Ernest Favre from his own observations and extracted from "Recherches géologiques "dans la partie centrale de la chaine du Caucase" (H. Georg. Geneva and Bâle, 1875) by the same author.

3212. Portfolio, containing **Maps** in **Copper-plate Print.**

3213. Portfolio, containing **Maps** in **Lithographic Print.**
Bau Deputation, Hamburg.

3213b. Portfolio, containing reductions of the survey sheets to scale of 1 : 4000, and trigonometrical chart, scale, 1 : 50,000 lithographed. *Bau Deputation, Hamburg.*

3213c. Portfolio, containing reductions of the survey sheets in scales of 1 : 1000; 1 : 4000, and 1 : 20,000 on copper plates.
Bau Deputation, Hamburg.

3215. Portfolio, containing **Maps** and **Drawings.**
Bau Deputation, Hamburg.

3216. Plan, 1 : 4000. Sect. IV. galvanoplastic relief plate.
Bau Deputation, Hamburg.

3128. Plan, 1 : 20,000; in frame under glass.
Bau Deputation, Hamburg.

3128a. Hamburg and its Environs. Scale, 1 : 20,000, engraved by H. Petters. *Bau Deputation, Hamburg.*

3129. Plan, 1 : 4000; in frame under glass.
Bau Deputation, Hamburg.

3129a. Plan of Hamburg and its Environs. Official edition. According to the land survey, &c., engraved by S. Siebert. Scale, 1 : 4000. *Bau Deputation, Hamburg.*

3216a. Galvanoplastic Relief Plate of Section IV. of the before-mentioned copper plate print. *Bau Deputation, Hamburg.*

3217. Relief Maps of Bergedorf.
Bau Deputation, Hamburg.

3217a. Two Relief Maps, one of the town of Bergedorf and its environs, produced from the lithographed sheets. Longitudinal scale=scale of height=1 : 4000, the other parts of the area of Bergedorf, produced from the transfer-print sheets drawn for that purpose on cartoon paper. Longitudinal scale=scale of height=1 : 1000. *Bau Deputation, Hamburg.*

As a basis for the survey of Hamburg, the geodetic labours of Councillor Schumacher, Astronomer, are made use of, and in particular the base measured by him in the neighbourhood of Hamburg, in Holstein, in the years 1820 and 1821. At the suggestion of Engineer Lindley, the technical adviser of the public buildings deputation until 1860, a new survey and the construction of a new map on the scale of 1:250 was resolved upon in the year 1845, chiefly for technical purposes, and the necessary triangulation for that object was executed by Dr. A. C. Petersen, under the direction of Schumacher.

In the year 1863, the survey of the entire territory was commenced in connexion with that of the city for the Doomsday Book (land registry), and concluded in the year 1868. The additional triangulation work required for that purpose, which was commenced simultaneously with the divisional survey, was connected with the already determined trigonometrical points of the town, and then with the Holstein base. The number of trigonometrical points amounts to 1663, and the station points among the same, 993 in number, have been marked, with a very few exceptions, by granite pillars sunk into the ground. The angles were repeatedly measured by means of an 8-inch theodolite; the trigonometrical network corrected and adjusted according to the method of least squares, which was followed by the calculation of the horizontal rectangular co-ordinates, from which the geographical position was deduced by a very simple method. As origin of the system of co-ordinates, the spire of the large St. Michael's Church had already been fixed upon, and its geographical position determined as follows:—

Latitude = 53°, 32′, 55·7″

Longitude E from Greenwich = 9°, 58′, 41·75″.

The bailiwick of Bergedorf, formerly belonging to the joint jurisdiction of Hamburg and Lübeck, having been incorporated with the territory of Hamburg, the survey was extended to this area; and for this district a new division of survey sheets was adopted since the introduction of the metre standard.

The scales employed in drawing the maps are:—1:250, and 1:1000; for the new division of the sheets 1:200, 1:500, and 1:1000. Exact levels are given all over the entire territory, and bench marks are durably established in sufficient number. Connected with these, special levelling will be carried out by means of distance and altitude measurement.

In the adjoining parts of the territory not belonging to Hamburg, so far as it is to be included in the maps to be published, levels will be taken by means of aneroid barometers, on the Reitz system.

The reduction of the survey sheets is effected by means of a specially constructed pantograph.

The multiplied copies will be published in scales of 1:1000, 1:4000, 1:20,000, and 1:50,000 (**3213b** and **c**), by O. Meissner and Behre, Hamburg.

According to the directions given in the plates for the distance and the altitude measurements, the latter will be executed by the tachymeter, **3079a**. An ordinary levelling staff, divided into centimetres, will be employed for the purpose. A survey field book illustrates the work actually executed for a portion of the bailiwick of Bergedorf.

The co-ordinates of the station points required for levels will be calculated from those of known trigonometrical points, or from the polygon points of the detail survey, and entered in the survey sheets. In the principal polygons the distances between the station points will be measured with chains, or steel tapes, and the altitudes determined by levelling. A synoptical table of results obtained by distance and altitude measurements, with the directly executed longitudinal measurements and with the actual levellings, is given. It should be mentioned that this work was executed in November 1874, in unfavourable weather, and that more satisfactory results are obtainable by this method.

When the station points have been plotted on the survey-sheets, and the levels of the altitude points have been calculated from the field book, these latter are plotted on tracing paper, containing the sheet divisions, the station points, and more or less the situation of the respective survey-sheets. For plotting the altitude points a transferrer is used, made of paper; it is adjusted with its centre point under the corresponding station point, according to the horizontal angular measurements, and then all the altitude points based on this station are sketched on the tracing paper, their levels being noted. When all the altitude points have been marked down, the position of the intervening contour lines, on the assumption that the slope of the the ground is uniform between two altitude points, can be determined by the construction of similar triangles; this operation can, however, be avoided by the use of the instrument (**3127a**) devised for this purpose. If, for example, the altitude heights marked 30.5^m and 32.2^m have been ascertained, the difference of which amounts to 17 decimeter, the two contours for 31 and 32 metres will fall between these two points. The edge of the mirror of the variable scale is applied to the two points; the cylinder is turned until 17 parts of the division projected on the paper by the mirror fall between the points; the cylinder is then moved in the direction of its axis until the corresponding divisional marks 30.5^m and 32.2^m have been reached, and the points of section of this line with the contours for 31 and 32 metres are marked off. A better general view of the surface of the country divisions is afforded by the models produced from these plans.

3229a. Portfolio, containing various publications; viz.—

(*a.*) "Vermessung der Stadt Hamburg, Verzeichniss der trigo- " nometrisch bestimmuten Punkte mit Netzkarte, Ham- " burg, 1848." (Survey of the city of Hamburg, table of the trigonometrically determined points with reticulated map of Hamburg, 1848), containing the rectangular co-ordinates of the points in the town and the nearest vicinity, with lithographed sketches, and division of sheets.

(*b.*) "Vermessung der Stadt Hamburg, Verzeichniss der trigo- " nometrischen Punkte nebst Dreieckskarte, Hamburg, 1872." (Survey of the city of Hamburg, table of the trigonometrical points with trigonometrical chart. The latter in a scale of 1 : 50,000.)

(*c.*) "Nivellements und Höhenbestimmungen von Hamburg " und Ungebung, ausgeführt abseiten des Vermessungs- " bureaus in den Jahren, 1869–1872. Mit einer Karte, " Hamburg, 1872." (Levellings and determination of the heights of Hamburg and its environs, executed by the Survey Department in the years 1869–1872. With a map, 1872.)

(*d.*) "Verzeichniss von Höhenpunkten in Hamburg und Umge- " bung, bestimmt durch geometrische Nivellements " abseiten des Vermessungs-Bureaus in den Jahren 1869 " bis 1872, Hamburg, 1872." (Table of the heights of Hamburg and its environs, as determined by geometrical levellings, executed by the Survey Department in the years 1869 to 1872, Hamburg, 1872.)

(*e.*) "Distanz- und Höhenmessung, Formeln und Tabellen " behufs Aufnahme und Höhenbestimmung, u.s.w. Ham- " burg, 1873." H. Stück. (Distance and altitude survey. Formulæ and tables for survey and determination of the heights, &c., Hamburg, 1873.) H. Stück.

(*f.*) "Ueber die Ausführung von Höhen-Messungen mit dem "Aneroid-Barometer. System Reitz, aus der Fabrik von "R. Deutschbein in Hamburg, u.s.w. Hamburg, 1874." (Levelling with the aneroid barometer. System of Reitz, from the manufactory of R. Deutschbein in Hamburg, &c., Hamburg, 1874.)

(*g.*) "Vermessung von Hamburg, u.s.w. 1873;" Kurze Darstellung der im Hamburgischen Gebiete ausgeführten geodätischen Arbeiten. (Survey of Hamburg, &c., 1873; short description of the geodetic works executed within the territory of Hamburg).

Bau Deputation, Hamburg.

3229. Tables for the Measurement of Heights and Distances. *Bau Deputation, Hamburg.*

3230. Field-Book of executed height and distance measurements. *Bau Deputation, Hamburg.*

3230a. Portfolio containing representations of the hypsometrical works, namely:—

(*a.*) Tables for distance and levels.

(*b.*) Tables for the staffs used for distance measurement and levelling.

(*c.*) Field-book, with distances and levels taken in a part of the area of Bergedorf.

(*d.*) Transferrer for plotting heights.

(*e.*) Table containing the stations and the polygon lines for the distances and levels executed in a part of the area of Bergedorf, with a synoptical summary of the results obtained by this method with reference to direct measurement of length, and with regard to actual levelling.

(*f.*) Sheet with annotations of the altitude points determined by distance and height measurement, and the one metre contours constructed from them; scale 1 : 4000 of part of the adjoining Holstein territory.

(*g.*) Sheet of one metre contours, with the stations and polygon lines; scale 1 : 1000, of part of the area of Bergedorf.

(*h.*) Plan of the town of Bergedorf, with one metre contours; scale 1 : 4000, lithographed.

(*i.*) Plan of part of the area of Bergedorf, with one metre contours; scale 1 : 1000, lithographed print on cartoon paper. *Bau Deputation, Hamburg.*

3218. Map of the Earth, projected on a regular **Dodecahedron.** *George H. Darwin.*

3219. Map of the Earth, projected on a regular **Icosahedron.** *George H. Darwin.*

In these maps, the representation of the earth is effected by supposing the globe to be inscribed to a regular dodecahedon or icosahedron, and then projected on the faces of the solid by lines radiating from its centre. The faces of the solid are then opened out and laid flat, in such a manner as to represent the equator by a straight line. In the case of the icosahedron the polar axis is supposed to pass through two corners of the solid. In the case of the dodecahedron, the polar axis is supposed to pass through the middle points of two opposite faces, and these two faces are cut up into triangles.

3219a. Great Spheroidal and Universal Atlas.
M. Hanicke de St. Senoch, Paris.

This work is divided into seven parts the first two of which are devoted to general geography.

1st part. Maps developed in the shape of a Planisphere, and showing from different points of view the comparative status of geographical knowledge. (9 maps.)

2nd part. Aspects of the terrestrial globe, seen in projection upon plans perpendicular to divers great circles corresponding to the position of the chief countries. (8 maps.)

The five other parts are devoted to detailed maps of the five parts of the world.

3219b. Map of France. *M. Hanicke de St. Senoch, Paris.*

3220. Maps in Relief, embossed in paper, showing rivers, towns, railways, &c.; also, in relief, mountains, valleys, and other physical features of the earth's surface.

Larger series, 23 in. by 21 in.

ENGLAND AND WALES.
SCOTLAND.
INDIA.
EUROPE.
AFRICA.
PALESTINE.

Smaller series, 10 in. by 8 in.

ENGLAND AND WALES.
SCOTLAND.
EUROPE.
PALESTINE.

Henry F. Brion.

3221. Four Tableaux of Original Models for composing a new relief atlas by means of stamp-printing.
Ed. Uhlenhuth, Anclam.

3223. Section of the Brocken Mountain-group of the large relief map of the Hartz Mountain, composed in 1 : 25,000, according to the altitude curves of the plane-table sheets of the Royal Prussian General Staff, showing the layer formation in papier-mâché and wax. *Ed. Uhlenhuth, Anclam.*

3224. Brocken Group, executed in gypsum.
Ed. Uhlenhuth, Anclam.

3225. Terrestrial Globe of 80 cm. diameter.
Dietrich Reimer, Berlin.

3226. Terrestrial Globe of 34 cm. diameter.
Dietrich Reimer, Berlin.

3227. Terrestrial Globe on an iron stand with semi-meridian. *Dietrich Reimer, Berlin.*

3228. Terrestrial Globe. *Dietrich Reimer, Berlin.*

3231. Terrestrial Globe, 48 cm. diameter.
Ernst Schotte, Berlin.

3232. Four Maps. *M. Delesse, Paris.*

1. *Agricultural Map of France.*—On this map the various cultures or crops are shown by conventional colours, the shades of which are proportionately darker according as the returns or yields are more important.

If we consider the arable lands, which occupy the largest portion of France, they will of course vary yearly in their produce, but it is possible to form a money estimate of their average annual return per hectare.

By studying the figures for the cantons, taking into account their shape, as well as their elevation, and the mineral composition of the soil, curves have been traced showing the annual revenues of 20, 40, 60, 80, 100, and 120 francs.

For the woods, meadows, and vineyards, where the culture is permanent, there have also been traced curves of equal revenues, showing the average returns per hectare.

Giving to the cultivated lands, the woods, fields, and vineyards, their conventional colours, the depth of shade of these has been graduated according to the various curves to which they correspond.

Although the map is on a scale of 1:4,000,000, it nevertheless enables an estimate to be formed of how the agricultural riches of France is subdivided.

2. *Hydrological Map of the Seine and Marne.*—The hydrological map of the departments of the Seine and Marne is on a scale of 1:100,000, and shows the underground stores of water of the region of La Brie. These water supplies are represented by certain conventional colours, and their form has been determined by the geological investigation of the subsoil, from surveys and borings made over a network of wells. In fact, the surface represents the levels which have been ascertained for each well below the level of the sea, and these are shown by horizontal curves of 20 metres distance, so that it is very easy to trace the course of the flow of the water supplies.

In the region of La Brie, the principal subterranean water beds correspond with the most important argillaceous strata, that is to say, the green clays, the plastic clays, and in certain points, the building limestones of La Beauce.

Moreover the subterranean water-bearing beds known as those of infiltration correspond to the various watercourses which traverse La Brie, and especially the rivers, such as the Seine and Marne.

The water-bearing beds over the green clays is by far the most important in the plateau of La Brie, whilst in the valleys the wells are supplied by the beds of infiltration.

The hydrological map of the Seine and Marne enables a judgment to be formed of the depth it would be necessary to attain in order to obtain a water supply, and an opinion can also be formed of the geological nature of the soil which would be met with in boring. A judgment can also thus be formed of how the water sources and beds act in an absorbent soil like chalk; a question which is of considerable interest at the present time, when a tunnel is proposed between France and England.

3. *Lithological or Submarine Chart of the Seas of Europe.*—This chart, compiled from hydrographical observation, serves to convey an idea of the nature of the rocks which are covered by the seas of Europe.

The bed of the seas is characterised by horizontal curves traced from the depths ascertained by a great number of soundings. The beds distinguished are the stony rocks of various kinds, clays, mud, muddy sand, gravelly mud, sand, grit, and pebbles.

These are represented by conventional colours, as in geological maps, but one colour indicates the same lithological character. The localities most rich in shells are also determined and marked by shadings.

Among the rocks which form the bed of the seas, some are anterior to the present epoch, and are constantly worn or beaten, and are covered by deposits. They may be stony, like the granites or paving stones and the limestones, but they are occasionally tender and brittle like the clay, and sometimes movable like the sand and the pebbles.

The rocks anterior to the present period are seen principally in the parts which jut out along the coasts, in the straits, and in the localities where the tides run strongly. The rocks belonging to the deposits of the present epoch are essentially of the movable character, they fill especially the places having hollows or depressions; they cover the plateaux, and accumulate chiefly in depths where the tides or currents are not rapid.

The geological study of the coasts occasionally enables the prolongation of the rocks which have emerged to be traced beneath the sea, and portions of the geological submarine chart to be constructed.

4. *Ancient and present Seas of France.*—An endeavour has been made to represent the ancient seas of France in the silurian, the trias, the lias, the eocene, and the pliocene periods. Starting with the facts furnished by geology, there have been comprised in one blue tint all the points in which the existence of soils deposited by these various seas have been established. But these soils are not now what they were when originally formed; they have been partially destroyed by the atmosphere and by flowing water; they have been sundered by faults; they have been subjected to numerous and complicated overthrows; and it is chiefly their actual condition that it is proposed to describe. With this view, in order to study the lands in the parts where they are now visible, as well as in those where they are covered up, they have been represented in relief by means of horizontal curves. The curve having the side O is particularly interesting, as it shows the intersection of the actual level of the sea with the surface of the land under consideration, and, if we admit that the sea level remains constant, all the portions of land which are formed above this curve have necessarily been elevated.

The total of horizontal curves shows the orography of the superior surface of land, which has resulted from the wasting and changes since its deposition.

By the aid of these maps we can well see that while a basin has received the superposed soil, and the original elevations and depressions are to a certain extent maintained, they have thinned out successively in the more recent soils. Moreover, where a soil has been raised on the flanks of mountains, it presents generally a strong declivity, which is well shown by the approach of the horizontal curves, but disappears at a short distance from the mountains. The sixth map of the plate represents the actual seas of France, of which it shows the orography. It indicates also the proportion of carbonate of lime in the marine deposits which form on the shores, the upheaval and subsidence of the coasts, the distribution of the rainfall, &c.

3232a. Specimens of Charts published by the Navy Department.

Genéral Direction of the Depôt of Marine Charts and Plans, Paris.

Cherbourg Roads, 1836.
Directions of currents in the Channel, 1855.
Coasts of the mouths of the Rhône, 1848.
Coasts of Italy, 1863.
Approaches to Brest, 1868.
Island of Ouessant, 1868.
Guadaloupe, 1874.
Japan, 1874.

3235. Collection of Maps and Plans.

M. Biard, Paris.

3236a. Collection of Maps, Plans, Plaster Casts, and Photographs. *M. Delagrave, Paris.*

3236b. Map of Travel, setting off by differently coloured tracings the relative antiquity and importance of the Roman roads. *M. Hayaux du Tilly, Paris.*

3237. Manuscript Map of British Isles, on rollers.

Wichmann, Hamburg.

3238. Collection of Models and Maps.

Frère Alexis, Gochet.

3239. Diagrams showing the amount of the **Misrepresentation of the Sphere** by plane maps in the most usual projections.

C. W. Merrifield, F.R.S.

3240. Lecture Diagrams (4) of Alpine Glaciers, of Switzerland, by the late G. V. du Noyer. Used in illustration of lectures at the Royal College of Science, Dublin.

Edward Hull, F.R.S.

3241. Working Model of a Geyser.

Prof. W. F. Barrett.

This is a lecture table arrangement constructed upon the method first suggested by Prof. Wiedemann, and illustrated on a large scale by Prof. Tyndall. Water is put into the tube and heated by a gas flame below. Under the pressure of the column of water, the boiling point is raised, and the pressure being lessened by the overflow of water into the basin, steam is suddenly generated, which ejects the water periodically to a considerable height. When the tube is cooled, the eruption from this small model can eject the water at least 20 feet high. A large form, on the same pattern, similarly ejects the water 30 or 40 feet high. The size of the larger model is as follows: Tube of galvanised iron, 7 feet long, 4 inches in diameter below, and 2 inches diameter above. Basin, say 4 feet in diameter. A spiral row of gas jets heats this larger tube one-third of the way up, as well as a large gas flame below.

3242. "Cadre-Mobile." Frame for wall maps and pictures used in schools. *Ernest Recordon (Geneva).*

3243. Guthe's School Wall Map of Hanover. Newly drawn by W. Keil. *Th. Fischer, Cassel.*

3244. G. Rohlfs' Three Months in the Lybian Desert, with photograph and map. *Th. Fischer, Cassel.*

Rohlf's volume forms the first part of the report on the Expedition for the Investigation of the Libyan Desert, carried out under the auspices of His Highness Ismail Pasha, Khedive of Egypt.

3245. Album of Printing Specimens. Colour-printing specimens for works by Lischke, von der Decken, Heuglin, Rohlfs, Pfeiffer, Dunker, &c. *Th. Fischer, Cassel.*

The album contains proofs in colour printing of plates from the geographical and natural history works of Heuglin, Von der Decken, &c.

3246. Journal of the Museum Godeffroy. Edited by L. Friederichsen. 3 vols., 4to. *T. C. Godeffroy, Hamburg.*

This journal is the scientific organ of the "Museum Godeffroy." It is almost exclusively devoted to the publication of the results of the investigations of the travellers of the Museum in the Pacific, and contains geographical, ethnographical, and natural history memoirs. The management lays particular stress upon the production of technically perfect figures of the novelties described, so that the plates accompanying the journal must be regarded as in many respects patterns of the most various modes of pictorial reproduction. Particular care is also devoted to the production of original maps.

3246a. Reproduction of the **Chart** made in 1500 by Tuan de la Cosa, Columbus's pilot, after his second journey with Columbus in 1493. *Archæological Museum, Madrid.*

This is taken from the original at the Ministry of Marine, at Madrid. It may be considered a Mapa-mundi. The part applying to America is most important, as it was drawn out by this pilot in the second journey which he took with Columbus in 1493. This chart was made for Queen Isabella, and contains the following inscription:—*Tuan de la Cosa la fizo en el Puerto de Santa Maria en Anno de* 1500.

This reproduction is accompanied by a memoir on the same subject, written by Dn. Fernander Duro, and published in the "Museo Español de Antiguedades."

3246b. System of Photo-Lithography as adopted in the Surveyor-General's Office, Adelaide.
The Royal Commissioners of the Exhibition of 1851.

3246c. Plans, Southern portion of South Australia.
The Royal Commissioners of the Exhibition of 1851.

3153e. Collection of Dried Plants from **Arctic Regions,** presented to Elizabeth Gurney. Collected by Sir Edward Parry.
Samuel Gurney.

Photographs of the **Yellowstone.**
J. Norman Lockyer, F.R.S.

SECTION 16.—GEOLOGY AND MINING.

WEST GALLERY, ROOM L and M.

I.—GEOLOGY.

1. SPECIAL COLLECTIONS. GEOLOGICAL SOCIETY OF LONDON.

a. GEOLOGICAL INSTRUMENTS AND APPARATUS.

3247. Apparatus, &c. employed in **Sir James Hall's** celebrated experiments. *The Geological Society of London.*

A series of specimens, with the instruments employed in their preparation, illustrating the remarkable experiments carried on by Sir James Hall, Bart., between the years 1787 and 1805, to confirm some of the positions taken up by Dr. James Hutton in his celebrated "Theory of the Earth." The series consists of the following:—

(1.) A selection of whinstone and lava rocks which have been fused and allowed to cool under various conditions. These are the products of the earliest experiments, which were carried on in ordinary clay crucibles.

(2.) Porcelain tubes employed in the first attempts to submit carbonate of lime and other substances to a high temperature under pressure.

(4.) "Gun-barrels," employed in the final and successful experiments for the same purpose; with the cylinders of rock operated upon.

(The collection of apparatus and specimens from which the above are selected was presented to the Geological Society of London by Captain Basil Hall, R.N., at his father's death.)

3248. Geological Model of the **South-east of England** and **part of France,** including the **Weald** and the **Bas Boulonnais.** Founded upon the maps of the Ordnance, Admiralty, and Geological Surveys. Scale, 1 inch to 4 miles. *W. Topley and J. B. Jordan.*

This model illustrates the close connexion which exists between the geological structure of a district and the "form of the ground." The chief hill ranges and the broad longitudinal valleys correspond with the outcrops of hard or soft rocks; the transverse valleys, in which the main rivers run, cut across all the rocks alike.

3249. Agricultural Map of **Kent.** Scale, 1 inch to 4 miles. *William Topley.*

This map is founded upon the published maps of the Geological Survey, additions and modifications of colouring for agricultural purposes being made by the author. Stiff and retentive soils are coloured dark tints—grey, purple, and brown; light and absorbent soils, yellow or light green; calcareous and absorbent soils, blue.

The index notes briefly the quality of the soils; the character of the land, whether chiefly arable, pasture, or woodland; and mentions a few of the more noteworthy crops of Kent.

3250. **Diagram** illustrating the comparative **Agriculture** of **England and Wales.** *William Topley.*

The object of this is to show the relative agricultural value of the various counties, which can best be done by exhibiting the per-centage acreage of the different crops. The numbers are obtained from the "Agricultural Returns" for 1869; the area of "woodland," and that of permanent pasture as divided between grass and hay, being added from the returns for 1871. The absolute numbers vary slightly in different years, but the variation of the per-centage numbers is very small. [For the results obtained from these maps and diagrams, *see* Journ. Roy. Agric. Soc., ser. 2, vol. vii., p. 268, 1871.]

3251. **Maps** and **Table** illustrating **William Smith's** first efforts towards producing his **Geological Map** of England.

The Geological Society of London.

(1.) Original table of the order of strata and their imbedded organic remains in the vicinity of Bath, as examined and proved by William Smith prior to 1799. The MS. is in the handwriting of the Rev. B. Richardson, of Farley, who wrote it down from the dictation of William Smith, in the year 1799.

(2.) A geological map of the district around Bath, prepared by William Smith about the same period.

(3.) Smith's first small geological map of England; in this the identification was effected by mineral characters, not by fossils, and the formations were traced by physical features.

(These maps were presented by William Smith to the Geological Society of London in the year 1831, on the occasion of his receiving at the hands of their president, Professor Sedgwick, their award of the Wollaston medal and donation fund.)

3252. **Maps** illustrating the rise and gradual progress of the art of **Geological Surveying** in the British Islands and the Colonies. *The Geological Society of London.*

Wm. Smith's first large geological map of England, published in the year 1815.

G. B. Greenough's geological map of England, the first edition, published in the year 1819.

Bain's first geological map of South Africa.

Bain's smaller geological map of South Africa.

John Phillips's geological map of Yorkshire, first edition.

Farey's section across the Weald.

Section across the Weald by John Farey in 1806.

This horizontal section from London to Brighton, upon the scale of 1 inch to a mile, was constructed by John Farey in 1806. It was never published, but several MS. copies were made of it. It is of great historical interest as being the first illustration of the anticlinal structure in the south-east of England, of the truncated chalk escarpments, and of the proofs of enormous denudation which must have taken place in the district.

3252a. Series of Indexes of Colours and Signs employed in the Maps and Sections of the Geological Survey of the United Kingdom.

The gradual advance of English geology (as expressed by maps) is shown to some extent by the successive editions of the Index of Colours used by the Geological Survey.

The earliest index (in MS. only) was drawn up by Sir Henry De la Beche, and shows the classification of rocks in use, and the extent to which geological surveying was carried in the year 1832.

In the first published index the volcanic rocks were indicated by green colours, but Sir R. I. Murchison, on becoming director-general in 1855, introduced the sytem of lettering the various formations, beginning with A for the Cambrian rocks, and altered the colouring of the igneous rocks to various shades of red. The results of these changes are shown on the second sheet.

In the index of colours published in 1856, the system of colouring, lettering, &c. then introduced will be seen to be essentially the same as that now in use. Various modifications have, however, since been made from time to time, for the purpose of representing the more numerous subdivisions of certain formations which it has become necessary to map, and some alterations have also been made in that part of the index which relates to the igneous and metamorphic rocks, so that the nomenclature of the maps of the Survey may approximate more closely to that of modern petrology.

3252b. Geological Map of Cornwall and West Devon. Ten Sheets on the scale of one inch to one mile, mounted together.

In this map the granitic masses of the S.W. of England are shown partly surrounded by Devonian rocks and partly by rocks of Carboniferous age, the latter overlying the Devonian rocks conformably, and filling up part of a synclinal trough, so that the Devonian rocks occupy superficial areas north and south of that composed of the Carboniferous rocks (culm-series). Dykes of Elvan (quartz-porphyry), which proceed from the underlying granite, are seen to trend in an east and west direction, while interbedded greenstones (rocks of a doleritic type, including beds of volcanic ash) follow the strike of the Devonian and Carboniferous rocks in various places. Masses of serpentine and diallage rock are likewise marked on the map, and also the tin, copper, iron, and lead lodes which occur in different localities, the stream-tin deposits being also indicated.

This map has a historical interest, since it is almost entirely the work of Sir Henry De la Beche, the founder and first Director of the Geological Survey of the United Kingdom. The publication of this map and the accompanying report on the geology of Cornwall, Devon, and West Somerset led to the recognition of the scientific and economic value and importance of a geological map of the country; to the institution of a Government geological survey under Colonel Colby, R.E., who was then Director of the Ordnance Survey; and afterwards to the foundation of the Museum of Economic Geology (now the Museum of Practical Geology), to illustrate the work of the Survey, and its practical application in mining, agriculture, architecture, and the fine arts. The Royal School of Mines was subsequently added, to afford facilities for the teaching of geology and the collateral sciences.

3252c. Geological Map of East Devon, Somerset, Dorset, and part of Wilts. (Scale, one inch to one mile.)

Ten sheets, on the scale of 1 inch to a mile, mounted together, illustrating not less than 53 formations in East Devon, Somerset, Dorset, and part of Wilts. The map includes the various tertiary beds of East Dorset, the chalk of Salisbury Plain and of Dorsetshire, including that of Ballard Down, together with the S.W. range of the Upper Greensand of Shaftesbury and Westbury, and to the west that of Black Down and Great Haldon.

The southern portion of the Jurassic formation in England forms a prominent feature in the map.

The Triassic Strata flanking the Mendips occupying extensive valleys between Watchet and Torquay.

The rocks composing the great anticlinal ridge of the Mendip Hills mark the boundary of the Somersetshire coal-field, which here is generally concealed by Triassic, Liassic, and Oolitic overlying formations; when, however, the coal measures are exposed, the coal seams are indicated by continuous black lines; these lines, when broken, show the extension of the seams beneath the overlying deposits. In the S.W. portion of the map the Devonian rocks of Totnes, Torquay, and Start Bay are shown, and also the Carboniferous and Devonian rocks of Mid Devon, and the easternmost portion of the granite of Dartmoor.

3252d. Geological Map of the Wealden Area.

In addition to the Wealden area, this map comprises the southern and main parts of the London Tertiary Basin and the eastern portion of the Hampshire Basin, which are separated from each other by the intervening parallel range of chalk hills, commonly known as the North and South Downs respectively.

The upper and lower cretaceous rocks, from the Upper Greensand to the Lower Greensand inclusive, appear in succession from beneath the chalk, forming an outer margin surrounding the Wealden area, which is separated from the central portion, consisting of the alternations of sand and clays (called the Hastings Beds), by the Weald clay, a broad belt of low and generally flat ground.

The model constructed by Messrs. Topley and Jordan (No. 3248) will convey a better notion to the eye of the general configuration of the ground than can be afforded by the map.

The latter, however, shows the undulations of the chalk, which forms large synclinal and anticlinal folds or elevations and depressions, and the enormous amount of cretaceous strata which once extended over the space between the North and South Downs, and which must have been removed by denudation.

3252e. Geological Map of North Wales, on the scale of one inch to a mile.

The rocks consist of the Cambrian and Lower Silurian strata, from the bottom of the Menevian beds to the top of the Bala beds, including the Bala limestone, with associated eruptive rocks and contemporaneous lavas and ashes, also of Upper Silurian strata of the Wenlock series, and of Old Red Sandstone, Carboniferous Limestone, Coal Measures, and Permian beds.

In Anglesea, the Cambrian rocks consist of grits and gneiss, and the Silurian strata of the island are also partly gneissic and associated with granite rocks. In Carnarvonshire, the Cambrian rocks largely consist of grits and purple slates, which are extensively quarried for slate, especially at Llanberis and Penryhn. In Merionethshire, the same formations consist chiefly of massive purple and green grits, with a little purple slate. The contemporaneous volcanic series occurs at the top of the Arenig, and also in the Bala series, the top of Snowdon being a calcareous volcanic ash contemporaneous with the Bala limestone. Most of this series is fossiliferous.

The Upper Silurian beds consist of the Denbighshire flag-stones and Wenlock shales, also fossiliferous.

The Old Red Sandstone (unfossiliferous) is sparingly developed in Anglesea and Denbighshire. The Carboniferous Limestone and overlying mill-stone grit and Coal Measures are shown in Anglesea, Denbighshire, and Flintshire, and these are in places succeeded by red Permian strata and by the New Red series.

3252f. Geological Map of Mid Wales, on the scale of one inch to a mile.

This map contains 17 quarter sheets, on the scale of one inch to one mile. It comprises part of the Silurian rocks of Wales, and the Old Red Sandstone of Herefordshire and Shropshire. Rocks of Lower Silurian age occur in the western portion of the district, the north-western area displaying intrusive and interbedded igneous rocks. To the S.E. there is a succession of beds of Upper Silurian and Old Red Sandstone age, while to the N.E. Lower Silurian rocks crop out, together with a small exposure of the Cambrian rocks in the neighbourhood of Church Stretton. A portion of the Shropshire coalfield is included in the N.E. part of the map, and also the overlying Permian and Triassic formations of Shrewsbury. The localities where lead ores occur are indicated by the usual symbols.

3252g. Geological Map of the Midland Counties, N.W. Division.—Six sheets on the scale of one inch to one mile, mounted together.

The Carboniferous Limestone of Derbyshire, coloured pale blue on the map, occupies almost the central portion. The interbedded basalts (Toadstones) are shown, and also the metalliferous lodes (mostly lead ores).

This tract is traversed by the Pennine anticlinal axis from which the strata dip away to the east and west, the Yoredale Shales, Sandstones, and Limestones, and the Coal Measures, appearing successively on either side. To the eastward these form the Nottinghamshire and Yorkshire coal-fields, and are overlaid by Permian Sandstone, Magnesian Limestone, and various Triassic strata, but they are cut off to the westward by the boundary fault, which running nearly N.N.W. by Congleton brings the Carboniferous Limestone against the Trias. Near Stockport the Coal Measures reappear as the continuation of the Lancashire coalfield; and further south, near Stoke-on-Trent and Newcastle-under-Lyne in the N. Staffordshire coalfield, south of the limestone tract, the Carboniferous rocks are concealed by Triassic beds, but they reappear in the Leicestershire coalfield, part of which is seen in the S.E. corner of the map. Towards the west a large area is occupied by the Triassic Marls of Cheshire, in which extensive deposits of rock-salt occur.

3252h. Geological Map of the Midland Counties, S.E. Division.—Six sheets, on the scale of one inch to one mile, mounted together, illustrating the geology of the whole or parts of nine counties in central England.

The Oolitic rocks cross the map diagonally from N.E. to S.W. The strata in which the Northamptonshire iron-ores are worked are indicated on the map. Towards the S.E. these limestones and sandstones are succeeded by the Oxford Clay, which, after forming the flat districts around Huntingdon and Bedford, passes beneath a second escarpment of the Cretaceous rocks, running roughly parallel to the first. A small portion of the Lower Tertiaries of the London basin occurs in the S.E. corner of the map. To the N.W. of the Oolitic feature the Lias and Trias form the broad undulating country of Leicestershire, while in the N.W. corner of the map a great part of the Warwickshire and Leicestershire coalfields are shown.

3252k. Geological Map of the Lancashire Coalfield, scale six inches to one mile.

The area comprised in the sheet includes on the north Preston and Burnley, and on the south St. Helens and Manchester.

The principal coal-seams of the district are shown, and also the great lines of fault which displace the coal-bearing strata. The horizontal sections, on the scale of six inches to one mile (for height and distance), illustrate the sheet, one showing the Dukinfield Colliery and the various seams of coal through which the shafts are sunk; the other, the structure of the Manchester coalfield and adjoining country. A vertical section, on a scale of 40 feet to an inch, of the Lancashire and Cheshire coalfields, shows the various seams of coal worked at Dukinfield and other collieries, and the relative thickness of the sandstones, shales, and other strata connected with them.

Horizontal and vertical sections descriptive of the Yorkshire coalfield are also shown.

3252l. Geological Map of a portion of the Yorkshire Coalfield (on the scale of six inches to the mile); the topography by the Ordnance Survey, the geology by the Geological Survey of England and Wales.

The geological formations shown on the map are (top) Magnesian Limestone (blue), Middle Coal Measures (black), Lower Coal Measures (pale black), Millstone Grit (still paler black); in the Coal Measures and the Millstone Grit thick beds of sandstone are denoted by yellow and other colours spread over the general black tint; the positions of faults at the surface are shown by white lines, and where faults have been proved in workings, their corresponding positions in beds of coal are denoted by yellow lines; black lines are the outcrops of coal seams. The depths of coal pits, and where possible the thickness of the coals passed through, and sundry other geological and mining details, are engraved on the maps. In looking at the map it must be borne in mind that its object is to show what rock it is that forms the surface at each spot, and that the fact that the surface at different spots is formed of different rocks is owing to the inclination of the strata. If the beds lay flat, we should have the same rock extending over nearly all the area. But the beds do not lie flat; over a great part of the country they slope or dip in a general way from south-west to north-east. In consequence of this dip the lowest beds (Millstone Grit) come up to the surface at the south-west corner; as we go thence in a north-easterly direction the Millstone Grit passes away underground and is covered up by the Lower Coal Measures; these in their turn are carried down and hidden beneath the Middle Coal Measures. The dip is steepest on the south-west, and decreases towards the north-east till the beds become flat and at last turn up and begin to dip towards the south-west, so that the measures, as far as we can see them, lie in a basin. How far towards the east this basin extends we cannot say, because, soon after the change of dip occurs, the Magnesian Limestone comes on and hides the Coal Measures from view. Besides the rocks mentioned the flats of alluvial river-mud and gravel are distinguished by a pale straw colour; old river gravels, deposited when the rivers flowed at a higher level than now, by a reddish brown tint; and some few patches of Boulder Clay and Gravel by stippling.

3252m. Index Geological Map of Wales, scale four miles to one inch, being a reduction of the one inch Geological Survey map of the same district.

Vertical section of the Purbeck strata of Dorsetshire.
Vertical section of the Tertiary strata of the Isle of Wight.
Horizontal sections of the Isle of Wight.
Horizontal sections of Dorsetshire coast, &c.

3252n. Geological Survey Map of Ireland, scale one inch to one mile.

The Geological Survey map of Ireland shows the state of progress to the present time. The coloured maps are published, those uncoloured are in various stages of progress, while the northern portions of Ireland have yet to be geologically surveyed.

The map shows the central plain of Ireland formed of Carboniferous Limestone (coloured blue), having on the south the Galty, Commeragh, and other mountains, formed of Lower Silurian and Old Red Sandstone, rising to elevations of over 3,000 feet. Along the east are the granitic and Silurian mountains of Wicklow, reaching in Lugnaquilla a height of 3,039 feet. On the west are "the Western Highlands" of Mayo and Galway, consisting of granite, quartzite, schist, and other metamorphic rocks of Lower Silurian age, in the midst of which are Upper Silurian beds on both sides of Killary Bay. To the extreme south-west are the mountains and promontories of Kerry, formed of Old Red Sandstone, with some Upper Silurian beds at Sybil Head and Smerwick Bay. Carrantuohill, near Killarney, reaches an elevation of 3,404 feet, being the highest point in Ireland. Small coal basins (tinted dark), resting on flagstones and shales representing the Millstone Grit series, occur in counties Cork, Tipperary, Kilkenny, Leitrim, and Tyrone.

Edward Hull, F.R.S., Director.

3252o. Drawings illustrative of the Microscopic Structure of various English Eruptive Rocks, by Frank Rutley. *Geological Survey of England and Wales.*

1. Micaceous Felstone, × 37. Potter Fell, Long Steddale, Westmoreland.

This rock is one of the numerous dykes which occur in the Upper Silurian rocks of the lake district, and may be regarded as a good typical example of very many of them. It consists of crystals of Orthoclase and magnesian mica embedded in a felsitic matrix. A little Magnetite is also present. Of the different component minerals, only a few of the Felspar crystals are sufficiently large to be apparent to the naked eye. The mineral components of these dykes are the same as those of Minette, but the former rocks differ from the latter in containing less magnesian mica, and in some of the Orthoclase being well crystallized.

1*a*. Key to Fig. 1.

2. Devitrified Pitchstone Porphyry, × 25. Stoke Lane, Mendips, Somersetshire. In this section crystals of both orthoclastic and plagioclastic felspars are shown, containing some Viridite, and surrounded by the devitrified magma which characterises this rock.

2*a*. Chromo-lithograph of Fig. 2, by Messrs. Vincent Brooks, Day, and Son.

3. Dolerite, × 75. Charfield Green, 150 yards north of Railway Station, Gloucestershire.

The larger drawing shows a much altered crystal of Orthoclase, as seen by polarized light, exhibiting twinning upon the Carlsbad type. Several of the larger crystals which occur in this rock, but which are not shown in the drawing, may also be Orthoclase, while some of the smaller ones appear to be Plagioclase greatly altered. Pseudomorphs after Olivine are also plentiful in the rock, and the smaller drawing represents one of them.

3*a*. Chromo-lithograph of Fig. 3, by Messrs. Vincent Brooks, Day, and Son.

4. Basalt, × 50. Damery, Gloucestershire.

Composed of Plagioclase, altered Augite, and serpentine pseudomorphs, some possibly after Olivine and Magnetite.

4*a*. Chromo-lithograph of Fig. 4, by Messrs. Vincent Brooks, Day, and Son.

5. Minette, × 37. Near first Railway Bridge from Windermere Station, Westmoreland.

In this section crystals of magnesian mica are shown lying in a felsitic matrix.

6. Diabase, × 25. Knowles Hill, Newton Bushel, Devonshire.

This rock is mainly composed of an altered triclinic Felspar, Augite, Chlorite, Serpentine Quartz, and Pyrites apparently altered in places into Limonite. A little Apatite is also present. In the drawing the upper half of the field represents the section by ordinary illumination, while the lower half shows the remaining portion as seen by polarized light.

7. Minette, × 150. Washfield, three miles N.W. of Tiverton, Devonshire.

A much decomposed Minette, full of small cavities, which cause it to resemble a scoriaceous lava, but when examined microscopically many of these holes are seen to present definite hexahedral forms, from which no doubt crystals of mica have been removed. The black granules and crystals represent Magnetite in some, if not in all, instances. The matrix is felsitic.

8. Microscopic drawings illustrative of structure in some of the eruptive rocks of Somersetshire, Fig. 1, volcanic breccia × 25. Wrington Warren, near Bristol. Section etched with acid and drawn as seen by reflected light. The upper portion of the field represents part of a small fragment of fossiliferous limestone (showing crinoid remains).

Fig. 2. Portions of crinoid stems from one of the above limestone fragments, × 105.

Fig. 3. Doleritic matrix in which the above limestone fragments are imbedded, × 50.

Fig. 4. Crystals of Magnetite in Felstone, × 150. Near Downhead, Mendips.

Fig. 5. Amygdaloid in Dolerite, × 25. Uphill Cutting, Great Western Railway.

Fig. 6. Amygdaloid of Calcspar in Dolerite, × 45. Uphill Cutting, Great Western Railway.

8*a*. Mechanical autotype of Plate 8, by Messrs. Vincent Brooks, Day, and Son.

9. Microscopic drawings illustrative of structure in some of the eruptive rocks of Somersetshire.

Fig. 1. Pseudomorph after Augite, from Dolerite, × 175. Uphill Cutting, Great Western Railway.

Fig. 2. Outline of an Augite crystal (natural size), given for comparison with preceding figure.

Fig. 3. Plagioclase from Doleritic matrix of Volcanic Breccia. Wrington Warren, near Bristol.

Fig. 4. Ditto, showing banding by polarised light, × 100.

Fig. 5. Pseudomorph after Augite, from Dolerite, × 175. Uphill Cutting, Great Western Railway.

Figs. 6, 7, and 10. Calcareous bodies in Volcanic Breccia. Wrington Warren, near Bristol.

Fig. 8. Crystal of a Felspar in devitrified Pitchstone Porphyry. Stoke Lane, Mendips.

Fig. 9. Calcspar Amygdaloids in Dolerite, × 50. Uphill Cutting, Great Western Railway.

Fig. 11. Crystal of Titaniferous Iron from Felstone, × 350. Near Downhead, Mendips.

Fig. 12. Fragment of Volcanic Breccia (natural size). Wrington Warren, near Bristol.

The matrix is Doleritic, the imbedded fragments are Fossiliferous Limestone, probably of Carboniferous age.

Figs. 13 and 14. Magnetite crystals in Felstone, × 350. Near Downhead, Mendips.

9*a*. Mechanical Autotype of Plate 9, by Messrs. Vincent Brooks, Day, and Son.

b. MAPS, DIAGRAMS, &c.

COLLECTION OF MAPS AND SECTIONS LENT BY THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

3253a. Geological Map of the Keswick District, on the scale of 6 inches to the mile, with appended one-inch maps, sections, &c. *J. Clifton Ward.*

With this are exhibited three one-inch maps of the same district, one of which serves as a coloured index sheet to the large map, and shows the varied dips of the strata, while the other two serve as cleavage and glacial maps. Also a horizontal section at the foot of the large map on the six inch scale, ten horizontal sections on the one-inch scale, a section through the plumbago mine in Borrowdale, and twenty-four chromo-lithographic figures of the microscopic structure of rocks of the district.

3253aa. William Smith's original Geological Map of Hackness Hill, Yorkshire, being one of the earliest geological maps ever constructed on a large scale. *R. Turnbull.*

The maps of William Smith "the Father of English Geology" of the outlying mass of the Middle Oolite at Hackness, exhibit in a striking manner the great knowledge of their author and the able manner in which he traced and mapped their geological structure, and also pointed out its bearing on the agriculture of the district. The geological survey map of the same area, while it helps to form a comparison of the old and new style of mapping, at the same time shows that William Smith was well acquainted with the general details of this unique and somewhat obscure group of rocks.

Series of Views in the Cam Valley, near Bath, coloured geologically. This was the valley in which William Smith, the father of English geology, made his earliest discoveries. *W. Stephen Mitchell, LL.B.*

3253ab. Geological Survey Map of the same district for comparing the old and new style of geological surveying. *R. Turnbull.*

3253b. One-inch quarter-sheet, 101 S.E. of the Ordnance Survey (Keswick District), converted into a **Model** by Mr. Jordan, and this into a Geological Model by the exhibitor, showing the various geological divisions, dips, faults, and mineral veins. *J. Clifton Ward.*

The work here embodied is the result of the labours of the contributor as an officer of the Geological Survey, but the colouring of the model has been privately undertaken with a view to its presentation to the Keswick Museum of Local Natural History.

3253c. One-inch sheet, 101 S.E. of the Ordnance Survey (Keswick District), converted into a **Model** by Mr. Jordan, and with glacial information, including ice-scratches, boulder-transportation, and old lake-beds. *J. Clifton Ward.*

Prepared by the contributor for the Keswick Museum of Local Natural History.

3253d. Diagrams of **Microscopic Rock-structure;** photographs, coloured and uncoloured, enlarged from small water-colour drawings 1¼ inches in diameter, made direct from the microscope. *J. Clifton Ward.*

The photographs have been taken by the firm of Hennah and Kent, of Brighton, from small water-colour drawings made by the contributor, direct from the microscope, and 1¼ inches in diameter.

A. Spherulitic felsite, Carrock Fell, Cumberland.
B. Hypersthenite, Carrock, Cumberland.
C. Fine-grained band in Hypersthenitic rock, Carrock Fell.

Three uncoloured photographs, also taken from small water-colour drawings made by the contributor:

D. Chiastolite slate, Skiddaw, Cumberland.
E. Quartz felsite, St. John's Vale, Cumberland.
F. Skiddaw Slate, passing into quartz felsite, St. John's Vale, Cumberland.

The small coloured drawings from which these photographs have been taken, are (except in the case of D) also exhibited (*see* Plate C. 3253f.).

3252dd. Dunn's Geological Map of South Africa. *Edward Stanford.*

Marcon's Geological Map of the World. *Edward Stanford.*

Table of British Sedimentary and Fossiliferous Strata, by W. H. Bristow, F.R.S. *Edward Stanford.*

Diagrams of Natural History. *Edward Stanford.*

3253e. Coloured Diagrams enlarged from small water-colour drawings, 1¼ inches in diameter, made direct from the microscope by the contributor. *J. Clifton Ward.*

A.—*Cumberland Volcanic Rocks* (see also Plate A of small water-colour drawings contributed, 3253f.).

1. Lava, Brown Knotts, Keswick.
2. Lava, Wastwater. (Polarized light.)
3. Felsite, amid altered ash, Bleaberry Fell, Keswick.
4. Ash, Steel Fell. (Polarized light.)
5. Altered streaky ash, Base Brown.
6. ,, ,, (Polarized light.)
7. Altered ash, Hart Side.
8. Highly altered fine bedded ash, Great Gable.

B.—*Welsh Volcanic Rocks.*

9. Felstone, a metamorphosed ash, Rigghause End, Vale of St. John, Cumberland. (Polarized light.)
10. Felstone, Aran Mowddwy. Also represents the structure of Fig. 9. when viewed with plain light.
11. Felstone, Aran Mowddwy. (Polarized light.)
12. Felstone, Aran Benlynn.
13. Felstone, Llanberis Route, Snowdon.
14. Slaggy felstone or altered streaky ash, Llanberis Route, Snowdon.

NOTE.—The Welsh felstone probably represents the modern trachytes or quartz-trachytes, and the Cumberland lavas the modern trachy-dolerites and basalts.

3253f. Three Plates of small water-colour drawings, $1\frac{1}{4}$ inches in diameter, made direct from the microscope by the contributor, illustrating **Microscopic Rock-structure.**

J. Clifton Ward.

A.—*Modern Volcanic Rocks.*

1. Trachyte, Solfatara, × 40.
2. „ „ (Polarized light), × 15.
3. Leucitic lava of 1631, Vesuvius, × 15.
4. „ „ Alban Mount, Rome, × 14.
5. „ „ „ „ (Polarized light).
6. Lava of 1794, Vesuvius, × 6.
7. „ „ × 45.

Ancient Cumberland Volcanic Rock.

8. Lava, Eycott Hill, × 25.
9. „ Brown Knotts, Keswick, × 30.
10. „ near Wastwater. (Polarized light), × 15.
11. Felsite, amid altered ash, Bleaberry Fell, Keswick, × 60.
12. Ash, Steel Fell. (Polarized light), × 15.
13. Altered streaky ash, Base Brown, × 15.
14. Altered ash, Hart Side, × 20.

B. *Illustrating the Metamorphism of Volcanic Rocks around the Granites of Eskdale and Shap.*

1. Altered ash, Yewbarrow, × 50.
2. Altered contemporaneous trap (?) close to granite, × 50.
3. Same field of view, in polarized light, × 50.
4. Highly altered ash, close to granite. (Polarized light), × 50.
5. Bastard granite. (Polarized light), × 50.
6. True granite, × 50.
7. Junction of highly altered ash with Shap granite. (Polarized light), × 25.

C.

1. Altered Skiddaw slate passing into quartz felsite, Clough Head, St. John's Vale, × 30.
2. Quartz felsite, St. John's Vale, × 30.
3. Altered Skiddaw slate, Red Pike, × 70.
4. „ „ Buttermere, × 70.

5. Syenitic granite, Scale Force, Buttermere, × 30.
6. Spherulitic felsite, Carrock Fell summit. (Polarized light), × 10.
7. Hypersthenite, White Crags, Carrock. (Polarized light), × 10.
1. Fine-grained band in hypersthenite. (Polarized light), × 10.

3253g. Plates illustrative of **Structures** in **Felspars, Leucite, Obsidian,** and **Perlite,** from drawings made partly in pencil, partly in lamp-black, by Frank Rutley, F.G.S., H.M. Geological Survey. Plates I. and II. illustrate a paper in the Quart. Journ. of the Geological Society of London for Aug. 1875. Plates III. and IV. illustrate a paper in the Royal Microscopical Society's Transactions, March 1876.

Frank Rutley, Geological Survey Office.

PLATE I.

Fig. 1. Orthoclase, Arendal, showing crystals arranged in two directions, other than those of striation. × 50 (polarized light).
2. Felspar crystal in perlite, Schemnitz, Hungary, showing partial cross-hatching. × 55 (polar.).
3. Crystal in trachyte, Berkum, near Bonn, Rhine, showing internal curved divisional markings, with lines crossing at right angles in the lateral areas. × 115 (polar.).
4. Partially formed, or partially disintegrated crystal in obsidian, Mexico. × 175 (dark-ground illumination).
5. Patches of cross-hatched felspar in oligoclase, Twedestrand, Norway. × 115 (polar.).
6. One of the above patches, showing partial cross-hatching. × 350 (polar.).

PLATE II.

Fig. 1. Minute crystal in obsidian, Mexico. × 240.
2. Diagrammatic exaggeration of the above.
3. Crystal from trachyte, Berkum, Rhine. × 90 (polar.).
4. Crystal from basalt, Cleveland, showing rectangular banding and subordinate oblique striation, the latter possibly indicating planes connected with twinning on the Baveno type. × 45 (polar.).
5. Crystal in obsidian, Mexico. × over 100.
6. Crystals of plagioclase in gabbro, Volpersdorf, Silesia, showing bands at right angles. × 90 (polar.).
7. Crystal in basalt, Cleveland, Yorkshire. × 45 (polar.).
8. Fragment of plagioclase in basalt, Cleveland, showing alternately dark and light bands fringing an obliquely cut twin lamella, as in fig. 10. × 45 (polar.).
9. Crystals on edge of section of basalt, Cleveland, showing cross-hatched striation and a rectangular cleavage at *x* on the outer edge of the section. × 45 (polar.).
10. Diagrammatic vertical section through a section of plagioclase, cut obliquely to the twinning planes; the spaces marked *w* would alternately appear light and dark in different positions of the Nicols when seen by polarized light, the overlap of the complementary colours giving rise to white light.
11. Diagrammatic section similar to fig. 10, but cut more obliquely to the twinning planes, so that, instead of coloured bands separated by light or dark ones, an unbroken surface of white light might result, although the section might be that of a felspar many times twinned.

PLATE III.

Figs. 1, 4, 5, 6, 7. Structures seen in a thin section of spherulitic obsidian from the lava stream of Rocche Rosse, in the Isle of Lipari.
8. Portion of one of the spherulitic bands in the above rock. × 22.
12. Magnetite crystals partially converted into peroxide of iron, occurring in a crystal of leucite from Vesuvius. × 760.
2, 3, 9, 10, 11, 13, 14. Structures seen in a crystal of leucite, from Vesuvius.

PLATE IV.

Perlite, from Buschbad, near Meissen, showing the spheroidal structures lying between divisional straight lines F. F. F. F.

3253. Map showing the work of the **Geological Survey of Scotland,** on the scale of one inch to the statute mile. All the published sheets of the map are given here, and a few of which the survey is completed, but which are not yet engraved, are inserted in MS. At the foot of the map an example of the horizontal sections is given which are run across the country on the scale of six inches to the statute mile.

Geological Survey of Scotland, Prof. Geikie, F.R.S., Edinburgh, Director.

3254. Geological Map of the Ayrshire coal-field and adjoining districts, on the scale of six inches to the statute mile. This map has been selected as an illustration of the detailed work of the Geological Survey of Scotland. The whole county is surveyed on this scale, though only the mineral districts are published on these maps, the general map of the country (*see* No. 3253) being on the scale of one inch to a mile. At the foot of the map a MS. sheet is inserted to show the stages of progress in the field work of the survey. Two specimens are likewise given of the detailed vertical sections, on the scale of forty feet to the inch, which are published in illustration of the coalfields.

Geological Survey of Scotland, Prof. Geikie, F.R.S., Edinburgh, Director.

3254a. Geological Map of **England and Wales,** by the late Sir Roderick I. Murchison, Bart., K.C.B., &c. Fifth edition, with all the railways. Scale, 28 miles to an inch; size, 14 inches by 18. *Edward Stanford.*

3254b. Geological Map of **Ireland,** by the late Joseph Beete Jukes, M.A., F.R.S., Director of H.M. Geological Survey of Ireland. This map is constructed on the basis of the Ordnance Survey, and coloured geologically. It also shows the railways, stations, roads, canals, antiquities, &c., and when mounted in case forms a good and convenient travelling map. Scale, 8 miles to 1 inch; size, 31 inches by 38. *Edward Stanford.*

3254c. Geological Map of **London** and its Environs. Scale, 1 inch to a mile; size, 24 inches by 26. Compiled from various authorities by J. B. Jordan, of the Mining Record Office, and printed in colours exhibiting the superficial deposits. It includes Watford on the north, Epsom on the south, Barking on the east, and Southall on the west, and shows the main roads in and around the Metropolis, the railroads completed, and the sanctioned lines. *Edward Stanford.*

3254d. Geological Map of **Canada** and the adjacent regions, including parts of the other British provinces and of the United States, by the late Sir W. E. Logan, F.R.S., &c., Director of the Geological Survey of Canada. Scale, 25 miles to an inch; size, 102 inches by 45. On eight sheets. *Edward Stanford.*

3254e. Geological Map of **India.** General sketch of the physical and geological features of British India, by G. B. Greenough, F.R.S. With tables of Indian coalfields, minerals, fossils, &c. Scale, 25 miles to an inch; size, 68 inches by 80. On nine sheets. *Edward Stanford.*

3254f. Geological Map of the **World,** by Jules Marcou. Constructed by J. M. Ziegler. Size, 72 inches by 50. *J. N. Ziegler.*

3254g. Geological Sketch Map of **South Africa,** from personal observations (combined with those of Messrs. A. G. Bain, A. Wylie, T. Bain, jun., Dr. Atherstone, and R. Pinchin, in Cape Colony, together with those of Dr. Sutherland in Natal, and of Mr. E. Button), north of 24° latitude. Scale, about 35 miles to an inch; size, 33 inches by 28. *E. J. Dunn.*

3254h. Geological Map of the British Isles. *E. Best.*

2. MAPS, DIAGRAMS, FOSSILS, &C., EXHIBITED BY VARIOUS CONTRIBUTORS.

3257. Section of a **Well** at the **Hampstead Road,** showing detail depths of strata, 1840. *R. W. Mylne, F.R.S.*

3258. Five Outline Sections of the strata under **London,** with a block index plan, 1850. *R. W. Mylne, F.R.S.*

3259. Topographical and **Geological Map** of **London** and its environs.

100 square miles, scale 1·43 inch to a mile, 1851. *R. W. Mylne, F.R.S.*

3256. London and its **Environs Topographical** and **Geological.**

131 square miles, scale $\frac{1}{17032}$, English and French geological references, 1855. *R. W. Mylne, F.R.S.*

3255. Contours of London and its **Environs.** Plain and coloured geologically.

176 square miles, scale $\frac{1}{17032}$, 1856. *R. W. Mylne, F.R.S.*

3261. Geological Map of the **London** and **Paris Basins.**

The tertiary and cretaceous districts of England and the north of France, Belgium, Holland, and Denmark.

The coalfield areas and contoured depths of the adjacent seas, 1862. *R. W. Mylne, F.R.S.*

3260. Geological Map of **London** and its **Environs.**

159 square miles, scale 1·43 inch to a mile, with a longitudinal section of $18\frac{1}{4}$ miles, 1871. *R. W. Mylne, F.R.S.*

3253b. Table of Sedimentary Rocks, with a pamphlet.
Prof. E. Renevier, Lausanne, Switzerland.

3253c. Set of 12 Sopwith's Geological Models, with letter-press description. *Prof. Tennant.*

3253d. Ten Sheets of Geological Maps and Diagrams of Switzerland.

Prof. B. Studer, Geological Survey Commission of Switzerland, Berne.

3253e. Geological Map of the British Isles.
Society for Promoting Christian Knowledge.

3262. Map of the Bristol Coalfields and country adjacent, geologically surveyed by William Sanders, F.R.S.
Bristol Museum and Library.

The area of the map is 720 square miles. The topographical basis consists of a reduction to the scale of 4 inches to the mile of 218 parish maps. The geological lines are entirely the result of the author's personal surveys; about 20 years were devoted to the work. The map was published, in 1864, at the author's cost. In nineteen sheets. Folio. J. Lavars, Bristol.

A reduced copy, on the scale of one inch to the mile, in one sheet, was published in 1873.

3264. Geological Map of the British Isles, by Professor John Phillips, F.R.S.

Society for promoting Christian Knowledge.

3265. Geological Map of the Arctic Regions.
C. E. De Rance.

The topography is taken from the Chart accompanying the Admiralty correspondence connected with the British Arctic Expedition of 1875. The geological boundaries of Parry Islands, and the north coast of America, from the determination by Conybeare, Murchison, Salter, and Dr. Haughton—of the specimens brought back by the expeditions of Franklin, Parry, Back, John and James Ross, Sabine, Buchan, Beechey, Sherard Osborn, and M'Clintock. Those of West Greenland from the observations of Giesecké, Nordenskiöld, O. Heer, and Dr. Brown. Those of East Greenland and Spitzbergen from the results of the various Austrian, Swedish, and North German expeditions. Those of Hall Basin, and the channels lying north of Smith's Sound, from the labours of Drs. Kane and Bessels, which prove that the upper Silurian rocks, noticeable along the southern fringe of the Arctic Archipelago, reappear in this tract. The Lower Carboniferous Coal-bearing Sandstones, and overlying Carboniferous Limestones, lying in a basin.

3267. Model of the Cleveland Hills and district showing the outcrop of the main seam of Ironstone. *John Bell.*

3268. Geological Maps and **Model** of **New Zealand.**

1. Copy of the first geological map of the whole of New Zealand, prepared by Dr. Hector, and exhibited at the New Zealand Exhibition in 1865. This map was engraved by the Geological Department and published in 1869.

2. Geological sketch-map of New Zealand constructed from the official surveys of the Geological Department by James Hector, C.M.G., M.D., F.R.S., &c., director of the Governmental Geological Surveys, Wellington, 1873.

3. Relief-model of New Zealand on same scale as the Geological map (2), and with a vertical scale four times as great as that of the horizontal. This model is placed beside the geological map to illustrate the forms of the surface of the parts of country occupied by the different geological formations. Modelled by Dr. Hector, 31st March 1876. *James Hector, M.D., F.R.S.*

3268a. Geological Map and sections of a part of the Province of Koutais, published by the "Administration des Mines," 1873. *Mining Institute of St. Petersburg.*

3268b. Geological Map of a part of the Province of Bakou, published by the "Administration des Mines," 1872. *Mining Institute of St. Petersburg.*

3268c. Geological Map of Russia in Europe, begun in 1868 by the Members of the Mineralogical Society of St. Petersburg. *Mining Institute of St. Petersburg.*

3268d. Geological Map of the mining district of Outka, in the Oural, by M. Valérien de Moeller, 1875. *Mining Institute of St. Petersburg.*

3268e. Geological Map of the mining district of Ilim, in the Oural, by M. Valérien de Moeller, 1875. *Mining Institute of St. Petersburg.*

3268f. Sections of the mining districts of Ilim and Outka, in the Oural, by M. Valérien de Moeller, 1875. *Mining Institute of St. Petersburg.*

3268g. Geological Map of the southern part of the Province of Nijnii Novgorod, by M. Valérien de Moeller, 1875.
Mining Institute of St. Petersburg.

3268h. Geological Map of the Province of Wladimir, by M. Dittmar. *Mining Institute of St. Petersburg.*

3268i. Geological Map of Russia in Europe and the Oural mountains, executed by Murchison de Verneuil, and Keyserling, and completed up to 1870 by M. Helmersen.
Mining Institute of St. Petersburg.

3268j. Geological and Industrial Map of the western portion of the carboniferous district of Donetz, by Messrs. An. and Al. Nossow, 1873. *Mining Institute of St. Petersburg.*

3268k. Geological Map of the carboniferous district of the country inhabited by the Cossacks of the Don, executed by Messrs. Antipon Teltonochkine and Wassiliew, 1866–69.
Mining Institute of St. Petersburg.

3268l. General Geological Map of the carboniferous district of Donetz, executed under the direction of M. Helmersen, 1871. *Mining Institute of St. Petersburg.*

3268m. Geological Map of the southern portion of the Oural chain, by Messrs. Meglitsky and Antipon, 1855.
Mining Institute of St. Petersburg.

3268n. Geological Map of the western slope of the Ourals, by M. Valérien de Moeller. *Mining Institute of St. Petersburg.*

3268o. Geological Map of the Province of Kherson, by M. Barbot de Marny. *Mining Institute of St. Petersburg.*

3268p. Geological Map of the Province of Kiew, by M. Theophilaktow, 1872. *Mining Institute of St. Petersburg.*

3268q. Geological Map of the Town of Kiew, by M. Theophilaktow, 1874. *Mining Institute of St. Petersburg.*

3268r. Geological Map of the Province of Twer, executed by Messrs. Lahousen and Dittmar.
Mining Institute of St. Petersburg.

3268s. Geological Map of a part of the Province of Erivan, published by the "Administration des Mines."
Mining Institute of St. Petersburg.

3268t. Geological Map of the Province of Elisavetpol, published by the "Administration des Mines," 1869.
Mining Institute of St. Petersburg.

3268u. Geological Map of a part of the Province of Koutais, published by the "Administration des Mines," 1874.
Mining Institute of St. Petersburg.

3268v. Geological Map of the Province of Nowgorod, by M. Lahousen. *Mining Institute of St. Petersburg.*

4571. Drawing of **Two Sections** of the **Carnic** and **Julian Alps.** (One plate, m. 0·80 by m. 0·40.)
Technical School at Udine; Director, Torquato Taramelli, Professor of Physical and Natural Science.

3153b. Selection of Maps and Publications to illustrate the progress of the **Geological Survey of Spain.**
Comision del Mapa Geologico de España, Cath. de Isabel la Catolica, 23, *Madrid.*

(1.) Junta general de Estadistica.

Descripcion fisica y geologica de la provincia de Santander, por Don Amalio Marstre, second class inspector of the Society of Mining Engineers. 1 vol. Madrid, 1864.

(2.) Junta general de Estadistica.

Ensayo de Descripcion geognostica de la provincia de Teruel, by Don Juan Villanova y Pura. 1 vol. Madrid.

(3.) Boletin de la Comision del Mapa geologico de España. Vols. 1 and 2. Madrid, 1874–75.

(4.) Memorias de la Comision del Mapa Geologico de España.

Bosgnejo de una descripcion fisica y geologica de la provincia de Zaragoza, by Don Filipe Martin Donayre, first class engineer of the School of Mines. Madrid, 1874.

Descripcion fisica geologica y agrologica de la provincia de Cuenca, by Don Daniel de Cortarjar, mining engineer, and member of the French Geological Society. 1 vol. Madrid, 1871.

Trabajos geognosticos y typograficos practicedos por la Comision de Estudio de la Cuenca Carbonifera de Asturias. Madrid, 1874.

(5.) Mapa geologico de la provincia de Madrid, published by the Council of Statistics of the kingdom in 1864, and formed by Don Casiano de Prado, engineer of mines, member of the Commission of the Spanish Geological Map. 1854.

(6.) Mapa geologico de la provincia de Palencia, traced by Don Casiano de Prado, member of the Commission of the Spanish Geological Map, 1856.

(7.) "Cuadro grafico de altitudes de la parte septentrional de la provincia de Palencia," traced by the section under the direction of Don Casiano de Prado, member of the Commission appointed to form the Spanish Geological Map, 1856.

(8.) Plano geologico de la Cuenca carbonifera de San Juan de las Abadesas, province of Gerona, by Amalio Maestre, Madrid, August 15, 1855.

(9.) Comision del Mapa geologico. Secion geografica meterologica. Directed by the member and first class engineer, Dr. Jose Subercase.

(10.) Mapa geologico estratigrafico de las montanas de la provincia de Palencia, by Don Casiano de Prado, 1857.

(11.) Sections of the N. and N.E. of the province of Madrid, which include the Sierra of Truda, and cerros called de Concha within the limits of La Puebla de la Muger muerta.

3153c. Illustrations of the progress of **Geology, Mining,** and **Metallurgy** in **Spain,** selected from works published by the contributor. *Don B. Federico de Botella y de Hornos, Madrid.*

(1.) "Descripcion Geologica Minera de las Provincias de Murcia y Albacete (antigno reino de Murcia)," by B. Federico Botella y de Hornos, first class engineer of the National School of Mines, 1 vol., grand folio, 22 plates, and numerous drawings in the text.

(2.) Geological and agronomical plan of Murcia and the surrounding country, giving the system of irrigating canals employed at the Huerta of Murcia.

(3.) Sierra of Carthagena. Lead foundry. Spanish slag hearths. Atmospheric furnaces. Blast furnaces. Cementing furnaces. Compressed air furnaces used at the Escombrera Works.

(4.) Sierra of Carthagena. Desilverization. Condensing furnaces. Refining furnaces. Pattison's crystallizing boilers. Implements and tools employed in working these boilers.

(5.) Mazarron. General plan of alum works. Serrata of Lorca. Advantages of sulphur. Furnaces of horizontal cylinders. Furnaces of vertical cylinders.

(6.) Sierra of Carthagena. Metallurgy. Moulds used for mixing the bricks used at the furnace. Atmospherical furnaces. Moulds employed for pressing the lead out of the furnace. Silver in cupella. Blast furnaces, with ventilators and bellows. Moulds for casting leaden bars. Boilers and other implements.

(7.) Sierra of Carthagena. Mechanical preparations employed at the works. Works at Escombreras. Round buddles worked by steam. M. Victor Simon's classifier. Water clarifier.

(8.) Topographical and geological plan of the Sierra of Carthagena.

(9.) Sierra of Carthagena. Geological section from Cabera Gordo to Cerro de Santo Espiritu.

(10.) Sierra of Carthagena. Mechanical preparations used in metal works. American crushing machine. Classifying trommels. Dividing trommels. Refining trommel. Sieves. Classifying cones. Classifying cases. Concave rolling table. Lifter used for minerals.

(11.) Sierra of Carthagena. Cupellation. Cupellating furnace. General plan of desilverizing works.

(12.) Drawing representing a statuette of Hercules 0·152 met. H. found at the Esperanza mine in 1840.

Lamps, jars, and vessels of different kinds found at the mines of the Sierra of Carthagena.

Bronze lamp found at Lorca. Bas-reliefs. Fragment of a statue found in a mine of the Sierra of Carthagena. Lead bar of the Roman time, with inscription, found at the Sierra of Carthagena.

(13.) Sierra of Carthagena. Mechanical preparation used in lead works. Works at Escombreras. Crushing cylinders worked by steam. Vertical grinders. Classifying trommels. Sieves. Tables for shaking minerals.

(14.) Topographical and geological plan of the mines and works of San Juan de Riopar (province of Albacete).

(15.) Sierra of Carthagena. Geological sections.

(16.) A geological map of the provinces of Murcia and Albacete. (Spain).

(17.) Sierra of Lorca.

Fossil fish found in the sulphur mines.

(18.) Cerro of Mazarron. View of the vein of mineral of San Juan. Sierra of Orihuela. Peña del Gato. Sulphur mines at Hellin. View of the volcanic cerro of Monagrillo. Cerro of Mazarron. Section of an ancient excavation at Pedreras Viejas. View of the sulphur mines at Hellin.

(19.) Sierra of Carthagena. Mechanical preparation of minerals. Drawer sieves. Round buddles employed at the sierra. Cylinders used for crushing minerals worked by horse power. Sifters.

3331. Portions of the Geological Special Map of Prussia and the Thuringian States.

District of ILFELD, HARTZ ; 6 sections.
District of the OHM MOUNTAIN ; 6 sections.
District of JENA, on the SAALE ; 12 sections.
District of RIECHELSDORF ; 6 sections.
District of HALLE ; 4 sections.
COAL BASIN of SAARBRÜCK ; 13 sections.

Topographical Basis to a part of the above-named sections, representing the Outcrop of the Flötze; 6 sections.

The same sheets representing the Flötze in Projection; 6 sections.

Coal Measures (Carboniferous) and Permian formation of the vicinity of Halle, with the diluvium removed; 4 sections.

The same in profile.

Geological Agricultural Map of a part of the environs of Berlin.

Map, containing eight parts of the Special Geological Map of Prussia.

Seven Smaller Maps containing the explanations to the above.

Royal Geological Institution and Mining Academy of Berlin (Prof. Hauchecorne, Director).

3332. Geological and Agricultural Map of the manor of Friedrichsfelde, near Berlin, an example of a new cartographic method.

1. Map, scale $\frac{1}{5000}$.
2. Map, scale $\frac{1}{25000}$.
3. Length profiles, scale $\frac{1}{10000}$.
4. Map of ground rent, scale $\frac{1}{10000}$.
5. Die geognostisch-agronomische Kartirung, Text, Berlin, Ernst und Korn, 1875.

Prof. Dr. Orth, Berlin.

3333. Six large "Pedological" Plans.

I. & II. Profiles of soils which filter water.

III. & IV. Profiles of soils which do not filter water.

V. & VI. Profiles of rich soil suitable for the cultivation of the sugar beet.

VII. Text, Berlin, Wiegand, Hempel and Parey, 1876. Explanation to the above. *Prof. Dr. Orth, Berlin.*

The learned English physician, Dr. Lister, in the year 1683, proposed to the Royal Society of London, to prepare a map which should represent English soils and minerals, their distribution to be shown by special colours, &c. The above maps represent a new mode of geological "cartography," and exhibit the soil in its geographical position, and with its economical uses in a more precise manner than has hitherto been possible.

3339. Geological Map of the Bavarian Alps in a single plate. Scale $\frac{1}{100000}$.

Geological Survey of Bavaria (Dr. Gümbel).

3340. Geological Map of the Boundary Mountains, Eastern Bavaria. Scale $\frac{1}{100000}$. Sheet I.
,, ,, ,, II.
,, ,, ,, III.
,, ,, ,, IV.
,, ,, ,, V.
Geological Survey of Bavaria (Dr. Gümbel).

3341. Geological Sheet. Views of the Bavarian Alps.
,, Fichtelgebirge I.
,, Views from the eastern Bavaria boundary mountains.
,, Fichtelgebirge II. (in progress).
,, Views of the Fichtelgebirge.
Geological Survey of Bavaria (Dr. Gümbel).

3342. Four Single Sheets of the Original Geological Survey, showing the different stages of progress, scale $\frac{1}{5000}$.
Geological Survey of Bavaria (Dr. Gümbel).

3343. Geological Detail Sheet reduced from the single sheets, scale $\frac{1}{25000}$.
Geological Survey of Bavaria (Dr. Gümbel).

3344. Geological Sheet of a part of the Upper Bavarian Lower Miocene (Oligocene) beds.
Geological Survey of Bavaria (Dr. Gümbel).

These maps, while exhibiting the geological work done in Bavaria, also illustrate the mode in which the maps published on the scale of 1:100,000 have been produced. The land tax maps, scale 1:5,000, have been used for this purpose, and the observations made were entered on the spot (sheets 13–15), and afterwards geologically coloured. These observations have been then transferred to maps of a different scale 1:25,000 (Sheet No. 16), then to the military atlas 1:50,000 (No. 18), and lastly to the scale of those published 1:100,000 (1–11). Each original sheet may be obtained for the actual cost of production.

3269. Agricultural Map of Belgium.

(*a.*) Geology and mining. Geological models, horizontal and vertical sections.

(*b.* and *c.*) This map shows, by means of colours and signs, the mineral constitution of the soil of Belgium, based on the geological data, and the different kinds of cultivation. The agricultural land is divided into regions, and the latter into zones.

(*d.*) Height, $0{\cdot}45^{m}$; width, $0{\cdot}50^{m}$.

C. Malaise, Professor at the Government Agricultural Institute, Gembloux (Province of Namur, Belgium).

3270. Illustrations of the **Sub-Wealden Boring,** at **Netherfield,** near **Battle, Sussex.**

Contributed, on behalf of the Sub-Wealden Exploration Committee, by Henry Willett and W. Topley.

The Sub-Wealden boring was commenced in 1872, with the view of ascertaining the order and thickness of the secondary rocks beneath the south-east of England, and of determining, if possible, the depth and age of the Palæozoic rocks which are believed to underlie them. Geologists have for some years believed, chiefly in consequence of a paper published by Mr. R. Godwin-Austen in 1856, that beneath the secondary strata of the south-east of England there exists a floor of Palæozoic rocks, prolonged from South Wales, Gloucestershire, and Somersetshire on the west, and from Belgium and the north of France on the east. Amongst these Palæozoic rocks there is a possibility that coal-measures may occur; coal, in fact, is now worked beneath the Oolites in Somersetshire, and beneath the Cretaceous rocks in the north of France. It is only in this subordinate sense that the Sub-Wealden boring can be described, as it sometimes has been, as a "search for coal." The primary object is to learn what rocks underlie the Weald, this being a point of high scientific interest.

Such were the problems presented for solution. The methods employed and the results obtained are as follows:—A committee of reference was formed in London, with Prof. A. C. Ramsay as chairman; Mr. H. Willett, of Brighton, has throughout acted as hon. sec. and treasurer. The money has been mainly raised by private subscription, aided by grants from the Government, the Royal Society, and the British Association. Two borings have been made; the first was abandoned at a depth of 1,030 feet, owing to an accident to the rods. The second boring was commenced in Feb. 1875, and is now (in March 1876) 1,903 feet from the surface.

The specimens exhibited are arranged in two series; those on the top and second shelves are examples of fossils from the Kimeridge Clay, named by Mr. Etheridge. Those on the lower shelves are arranged in order of depth, the ends nearest the surface being placed on the left hand side of the bottom shelf; the examples in this series are mainly from the second boring, but a few specimens are added from the first boring—these are marked as such.

The work is performed by the Diamond Rock-boring Company. The rock is bored by a rapidly revolving "crown" set with diamonds; the débris are carried up to the surface by a stream of water which is forced down the hollow boring-rod. The "core" of rock rises within the enlarged space, or "core-tube, at the bottom of the rods; it is thus preserved, and is afterwards drawn to the surface. The machinery employed is shown in the photographs; an example of the boring "crown" is placed on the bottom shelf of the case; specimens of long "cores" extricated in solid masses as here shown are placed by the side of the case.

The second boring commenced with a hole 8 inches in diameter, yielding a 7-inch core; this was gradually reduced, owing to the necessity of lining the hole, until, at 1,670 feet, it was reduced to a 2-inch hole, yielding a 1-inch core.

The long diagram gives a detailed section of the strata passed through in the second boring, which may be grouped as follows:—

		Thickness.	Depth from Surface.
Purbeck Beds	Shales, limestones, cement-stones, and gypsum	200	—
Portland Beds	Sandstone	57	257
Kimeridge Beds	A variable set of strata; chiefly shales, and cement stones in the upper part, with many beds of sandstone and limestone in the lower part	1,512	1,769
Coralline Oolite	Oolitic limestone	17	1,786
? ?	Shales, sandy shales, and limestone	117	1,903
		1,903	—

There is still some uncertainty as to the relations of the lowest strata; they may belong to the Oxford Clay, or they may represent the lower Coralline series of Dorsetshire. This point will be cleared up as the boring progresses. The greater part of the Kimeridge Clay is very fossiliferous, some of the fossils being new to England; the least productive parts are the highly calcareous shales or cement stones; some of the limestones are mainly composed of small oysters; an example is shown in the small core at the side of the case.

The smaller diagram gives a section of the Cretaceous and Oolitic rocks of the south-east of England; distinguishing those previously known in that area from those discovered by the boring. The same point is brought out in the horizontal section, which also serves to illustrate the structure of the Wealden area. A simple inspection of these diagrams will show the amount of information already obtained by the boring. If the Palæozoic rocks should not be reached, the boring will still have yielded most valuable results, for we shall have acquired a knowledge of the Oolitic strata of this area, such as could not possibly have been obtained in any other way.

Some valuable beds of Gypsum were discovered in the Purbeck Beds; these are now being worked, giving rise to a new branch of industry in Sussex.

The position of the boring is shown in the Geological Model of the Weald which is exhibited in an adjoining case. Further details of the structure of the districts can be seen in the maps and sections of the Geological Survey.

3271. Geological Maps in relief, embossed in paper, of ENGLAND AND WALES, after Sir R. I. Murchison, and THE ISLE OF WIGHT, after H. W. Bristow, F.R.S. *Henry F. Brion.*

3272. Model of Etna. *Th. Dickert, Poppelsdorf, near Bonn.*

The model exhibited is a scientific work, much valued and used by all the larger institutes of Germany for illustration in their science classes.

3273. The Great Crater of Vesuvius. Photograph, showing the interior after the eruption of April 1872.

Robert James Mann, M.D.

This photograph was taken by Mr. J. M. Black from the gap in the broken edge of the rim. The top of the great rent, extending north and south through one side of the cone into the Atreo del Cavallo, is shown on the further side of the crater between the rounded and pointed eminences.

3274. Four Sketches representing a **Volcanic Eruption,** to illustrate the form.

Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

3275. Four Views of Crater Eruptions.

Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

The drawings are used as wall maps to illustrate geological lectures. For more information, *v.* Papers XI., XIII.

3276. Photographic Views (2) of Mount Sorrel granite quarries, Charnwood Forest, Leicestershire, by Messrs. T. and J. Spencer. *W. J. Harrison, Town Museum, Leicester.*

This rock is a tough hornblendic granite, largely used for revatt setts, kerbs, &c.

3277. Photographs of the slates and syenites of Charnwood Forest, and of a column of the hard rocks of Leicestershire erected in the grounds of the Leicester Town Museum.

W. J. Harrison, Town Museum, Leicester.

These rocks are coloured as Cambrian on the maps of the Geological Survey, but they have yielded no fossils, and the evidence of superposition is not clear, as the oldest rocks near are of Mountain Limestone. The views are by Messrs. J. Burton and Sons.

3278. Rock Sections. Series prepared for microscopical examination. *James How & Co.*

3281. Relief Map of the Habichtswald, near Cassel, province Hesse-Nassau; petrographically coloured.

Friedrich Sievers, Wehlheiden, near Cassel.

Constructed from the maps of the former electorate of Hesse, the level lines in which were taken at a distance of 60 Prussian feet apart, so that the surface of the North Sea is represented by 0.

The distribution of the rocks is shown in colours according to the observations of Dr. Möhl and the exhibitor, as follows :—

Carmine - - - the lower group of the "Bunter" sandstone, or New Red Sandstone.
Reddish yellow - - the upper group of the same.
Blue - - - "Muschelkalk."
Light-greenish grey - clay and sand with lignite.
Dark-greenish grey - marine sand rich in fossils, and septarium clay (Upper Oligocene).
White - - - alluvium.
Black - - - basalt.
Brown - - - basalt conglomerate.

Villages are shown in vermilion, railways and high roads in black, standing and running waters in blue, with corresponding figures referring to index, which is attached to the relief.

3285. Geological Sections. *University Museum, Oxford.*

Coast of Dorset, from Lyme Regis to Isle of Portland.
Slapton Sands, between Dartmouth and Plymouth.
Dunolly Castle, near Oban.
Brent Tor, near Tavistock.
View from Exmouth.
Parallel Roads of Glen Roy.
Section from Beerhead to Axmouth.
Country between Malverns and Cotswolds.
Coast of Dorset between Charmouth and Abbotsbury.
Submarine Forest of Stolford.
Views of the Coast of Devon E. and W. of Sidmouth (2).
Sections of Landslip.
Bird's Eye View of part of Devonshire.
View of Cliffs, Lyme Regis.

3287a. Microscopical Preparations of Spanish Rocks.
Francisco Quiroga, Madrid.

1. Spanish silicious diatoms.
2. Rutile from Horcaguelo (Madrid).
3. Molibdate of lead from Quentar (Granada).
4. Tourmaline from Buitrago (Madrid).
5. Tremolite from the province of Guadalayera, composed of tremolite and glass.
6. Meteorolite from Molina (Murcia), 24th December 1858; composed of pyroxene, peridot, and other metallic substances.
7. Meteorolite from Molina (Murcia), 24th December 1858; insoluble silicate produced by the action of acids; formed of pyroxene.
8. Meteorolite from Cangas de Onis (Asturias), 6th December 1866; it is formed of pyroxene, peridot, and metallic substances.

9. Dimyte from the Serrania de Ronda, formed of peridot picotite.*
10. Dimyte from the Serrania de Ronda, formed of peridot, picotite.*
11. Chrysolite from the Serrania de Ronda, formed of peridot, diopside.*
12. Serpentine from Sierra Parda (Serrania de Ronda), formed of peridot, serpentine, hematite.*
13. Serpentine from Sierra Parda (Serrania de Ronda), formed of serpentine, peridot, magnetite, hematite.*
14. Serpentine from Istau (Serrania de Ronda), formed of serpentine and magnetite.
15. Serpentine from Ystau (Serrania de Ronda), formed of serpentine and magnetite.
16, 17. Serpentine from Real del Dugue (Serrania de Ronda), formed of serpentine and magnetite.
18. Serpentine from Ronda, formed of serpentine and magnetite.
19. Serpentine from Torrevieja (Alicante), formed of serpentine and magnetite.
20–22. Serpentine from Barranco de San Juan (Granada), formed of serpentine and magnetite.
23. Serpentine from the Sierra of Guejar (Granada), formed of serpentine and magnetite.
24. Chlorite state of Cogulludo, formed of chlorite and magnetite.
25. Anthrakonite from Galicia, formed of fetid calcite.
26. Nummulitic limestone from San Vicento de la Barguera (Santander).
27. Cipolin from Robledo de Chavela (Madrid), formed of calcite and muscovite.
28. Chloritic limestone from Almaden, formed of calcite chlorite.
29. Obdurate clay of Segovia (cretaceous period), formed of clay, quartz.†
30. Clay slate of Peña de Penilla (silurian age), Segovia, formed of clay, feldspar, and quartz.
31. Talcose slate of the Escorial, formed of talc, quartz, and muscovite.
32. Felsyte from the Barranco del Cebollon, Granada, formed of felsyte, quartz, amphibole.
33, 34. Felsyte from the Escorial, formed of felsyte alone.
35. Felsyte from Peguerinos (Avila) formed of felsyte, quartz.‡
36. Granite from Robledo de Chavila (Madrid), formed of orthoclase, quartz, muscovite, and hornblende.
37. Gneiss from Chapas de Marbella (Serrania de Ronda), formed of orthoclase, quartz, muscovite, apatite.§
38. Gneiss from Mijas (Serrania de Ronda), formed of orthoclase, quartz, and muscovite.
39. Garnetiferous gneiss from Huertal (Granada), formed of orthoclase, quartz, muscovite, garnet, and picotite.
40. Gneiss from Robledo de Chavila (Madrid), formed of orthoclase, quartz, muscovite, and hornblende.
41. Gneiss from the Escorial, formed of muscovite and quartz and orthoclase.
42. Micaceous gneiss from the Escorial, formed of muscovite and quartz.

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* Brevis apuntis auria del origen peridotico de la serpentina de la Serrania de Ronda, by Don T. Macpherson. Anales de la Sociedad Española de Historia Natural, J. iv.

† Excursion geologica por la provincia de Segovia, por Don Alfonso de Aristo y Sarrinaga y Don Francisco Quiroga y Rodriguer. Anales de la Socd. Española de Hist. Natural, J. iii.

‡ Anales de la Soc. Esp. de Hist. Nat. J. iv, Actas, p. 73, sesion del 1 de Setz. de 1875. Paper read by F. Quiroga.

§ See (*), Memoria 10bre la estructura de la Serrania de Ronda, by T. Macpherson. Cadiz, 1874.

43. Coccolite with garnetite from the Escorial, formed of diopside and garnet.
44. Coccolite from Riara (Segovia), formed of diopside, garnet, hematite, quartz with fluid cavities, and apatite.*
45. Coccolite from Riarja (Segovia), formed of diopside and hematite.
46. Coccolite with garnetite from Riarja, Segovia, formed of diopside and garnet.
47. Garnetite from Riarja (Segovia), formed of garnet and diopside.
48. Hyalomicte from Riarja (Segovia), formed of quartz and muscovite.
49. Ophite from Puerto Real, Cadiz, formed of plagioclase, augite, diallage, epidote, hornblende, magnetite.†
50. Ophite from Puerto Real (Cadiz) formed of felspar, hornblende, magnetite.
51. Diabase from the Sierra de Cordova, formed of plagioclase, chlorite, augite, magnetite.
52. Garnetiferous amphibolite from Pedraya de la Sierra (Segovia), formed of amphibole and garnet.
53. Garnetiferous amphibolite from Pedraya de la Sierra, composed of amphibole and quartz with fluid cavities.
54. Quartziferous amphibolite from the escorial, formed of amphibole and quartz.
55. Quartziferous ampbibolite from Dilar (Granada), formed of amphibole and quartz.
56. Garnetic quartziferous amphibolite from Toril de Dilay (Granada), formed of amphibole, quartz, garnet, and picotite.
57. Quartziferous amphibolite from Laguna de Bacares (Granada), formed of amphibole, quartz, and picotite.
58. Quartziferous amphibolite from Barranco de les Araligos (Granada), formed of hornblende and quartz.
59. Quartziferous amphibolite from Barranco de los Àraligos (Granada), formed of hornblende and quartz.
60. Quartziferous amphibolite from Barranco de los Araligos (Granada), formed of hornblende, quartz, garnet, and hematite.
61. Quartzdiorite from Almaden, formed of plagioclase, hornblende, magnetite, quartz, with apatite.
62. Quartzdiorite from Almaden, insoluble from the action of acids.
63. Diorite from Peguerinos (Avila), formed of plagioclase, hornblende.‡
64. Idem from Peguerinos (Avila), formed of plagioclase, hornblende.
65. Idem from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, augite.
66. Idem from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, viridite, calcite, and quartz.
67. Diorite from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, viridite, and augite.
68. Trachyte from Cartagena, formed of sanidin, horublende, magnetite.
69. Trachyte from Telde (Grau Canaria), formed of sanidin, magnetite.
70. Trachyte from Guia (Grau Canaria), vide No. 8 of the collection of Grau Canaria Rocks, by M. S. Calderon, formed of sanidin, magnetite, hornblende.§

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* Observaciones sobre algunas rocas de Riarja (Segovia), by Quiroga. An. de la Soc. Esp. de Hist. Natural, J. v.

† Bosquijo geologico de la provincia de Cadiz, por T. Macpherson. Cadiz, 1872, and An. de la Soc. Esp. de Hist. Nat., J. v.

‡ Anales de la Soc. Esp. de Hist. Nat., J. iv., Actas, p. 73, sesion del 1 de Setz. de 1875. Paper read by F. Quiroga.

§ Resiña de las rocas de la Isla Volcanica Grau Canaria, por Salvador Calderon. An. Soc. Esp. de Hist. Natural, J. iv.

71. Trachyte from Palmas (Grau Canaria), vide No. 5 of the collection of Grau Canaria rocks of M. S. Calderon, formed of sanidin, magnetite.
70. Trachyte from Grau Canaria, vide No. 7 of collection of Grau Canaria rocks of M. S. Calderon, formed of sanidin, magnetite, augite, hornblende.
73. Trachyte from Grau Canaria (No. 9 of collections of Grau Canaria rocks, by M. S. Calderon, formed of sanidin, magnetite, hornblende.
74. Trachyte from La Cumbro (Grau Canaria), No. 3 of the collection of Grau Canaria, by M. S. Calderon, formed of sanidin, magnetite, augite, aragonite.
75. Tufa from Artenaza (Grau Canaria), No. 53 of the collection of Grau Canaria of M. S. Calderon, formed of sanidin, clay.
76. Plagioclase dolerite from Salto del Castellano (Grau Canaria) No. 45 of the collection of Grau Canaria rocks, by M. S. Calderon, formed of plagioclase, augite, and magnetite.
77. Basalt from Las Palmas, Grau Canaria, No. 40 of collection of Grau Canaria rocks of M. S. Calderon, formed of augite, magnetite, olivine, plagioclase.
78. Basalt from Las Palmas, Grau Canaria, No. 39 collection Grau Canaria rocks of M. S. Calderon, formed of augite, magnetite, olivine, plagioclase.
79. Plagioclasbasalt from La Cumbre (Grau Canaria), vide No. 53 of collection of Grau Canaria rocks of M. S. Calderon, formed of plagioclase, augite, magnetite, hematite.
80. Nephelinebasalt, from La Cumbre (Grau Canaria), No. 36 of the collection of Grau Canaria of M. S. Calderon), formed of nepheline, augite, magnetite, plagioclase, hematite.
81. Rosed felsyte from the Escorial, formed of felsyte and hornblende.
82. Serpentine from Burgos, formed of serpentine, diallage, magnetite.
83. Phonolyte from Agacte, Grau Canaria (No. 23 of collection of Grau Canaria rocks of M. S. Calderon), formed of sanidin, nepheline, hornblende, sphene.
84. Leptynyte from Sierra de Guadarrama, formed of orthoclase, quartz, muscovite, apatite.
85. Diorite from Peguerinos (Avila), formed of plagioclase, hornblende, magnetite, augite.
86. Diorite from Buitrago (Madrid), formed of plagioclase, hornblende, magnetite.
87. Ophite from Pando (Santander), formed of plagioclase, augite, diallage, hornblende, viridite epidote, magnetite.*
88. Ophite from Pando (Santander), treated by acids, formed of plagioclase, augite, diallage, epidote.
89. Altered ophite from Pando (Santander), formed of plagioclase, augite, diallage, magnetite, and viritite.
90. Garnet fils of Riaza (Segovia), formed of garnet, hornblende, plagioclase.†

3288. Geological Sections of five proposed lines of railway through the counties of Surrey and Sussex, from Brighton to London, made and surveyed in 1837, by Joseph Gibbs, C.E., and Arthur Dean, C.E. *Free Library and Museum, Brighton.*

South-Eastern, Brighton line, from Carlton Hill, Brighton, to junction with the Greenwich Railway. Direct line, from Church Street, Brighton, to junction with the Greenwich Railway. Gibbs' line, from Western Road, Brighton, to junction with the Croydon Railway. Stephenson's line, from North Lane, Brighton, to Nine Elms. Line without a tunnel, from Brighton to Kennington Oval.

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* Opita de Pando (Santandar), por F. Quirago au de la Soc. Esp. de Hist. Nat., J. V.
† Vide Elemente de Pelographic von Du. A. von Lasaulx. Bonn, 1875.

3289. Sections showing the positions of the **Palæozoic Rocks** beneath the Tertiary or Secondary Strata, with some specimens of the former. *Prof. Prestwich, Oxford.*

1. Section of the Kentish Town Well, London.
2. Specimens of some of the strata passed through in the above well.
3. Section of the Artesian Well boring at Ostend.

3290. Geological Section from **Paris** to **Brest.**
Delesse, Paris.

This outline section has been executed, under the direction of M. Mille, Chief Engineer, Ponts et Chaussées by Messrs. Triger, Delesse, and Guillier. It is on a scale of 1:40,000 horizontal, and 1:2,000 vertical. It follows the line of the railway which, leaving Paris, passes by Bonneval, Chateaudun, Vendome, Tours, Angers, Nantes, Vannes, and Quimper, and comes out at Brest. Many classic regions are traversed in this line, as the Paris basin, Beauce, Touraine, the Valley of the Loire, and a part of Brittany.

On this section can be followed the succession of the different geological strata, which are marked the whole length of the railway; their position is determined by their height above the level of the sea, so that, notwithstanding the exaggeration of the scale of elevation, it is easy to ascertain their relative position.

In the regions of La Beauce the subterranean sources of water supply have been specially studied.

This section also affords information as to the materials of construction furnished by each geological stratum, and the vegetable soil and the nature of the crops.

Geological studies of this kind are eminently useful if they precede the formation of railways, because they supply a knowledge of the difficulties likely to be encountered during the course of construction, as well as the resources which may be reckoned on in each region traversed; and even when made after the completion of a railway, they supply facts highly useful to science and industry.

In pursuance of the orders of M. de Franqueville, Director-General, Ponts et Chaussées, these geological surveys have been carried on by M. Mille over a great part of France.

3291. Original Sketches, illustrative of **Geological Scenery** and sections, taken by Dr. Buckland between 1815 and 1840. *The Oxford University Museum, Geological Section.*

1. Landslip, Lyme Regis.
2. View of Coast near Lyme Regis.
3. View of Coast near Sidmouth.
4. View of Coast near Sidmouth.
5. Submarine Forest of Stolford near Bridgewater.
6. View of Coast between Charmouth and Abbotsbury.
7. Bird's eye view of Dartmoor and south coast of Devon.
8. View of Vale of Severn between Malverns and the Cotswolds.
9. Coast view between Beerhead and Axmouth.

10. Parallel roads of Glen Roy.
11. View of Exmouth.
12. Brent Tor near Tavistock.
13. Dunolly Castle near Oban.
14. View of Shapton Sands.
15. View of south coast of Lyme Regis with Portland in the distance.

3292. Geology. Collection of specimens of felspars and amphibolitic rocks from Belgium and the French Ardennes. This collection comprises about 20 specimens, average dimensions 10 centimètres by 15.

Six chromolithographs of drawings of minerals and rocks as seen through the microscope. *A. Renard, Louvain.*

3293. Specimens illustrating the production by **Compression** of **Natural** and **Artificial Slaty Cleavage.** *H. C. Sorby.*

Specimens of slate rocks, showing, by various facts, that they have been greatly compressed in a line perpendicular to the cleavage.

Pipe-clay mixed with portions of blue paper, and also with iron scales, being the results of the first experiments made to show that a structure like that which causes the cleavage in slates can be artificially produced by pressure.

Artificial cleavage in compressed flaky graphite, being as perfect as that in any slate rock.

3294. Specimens illustrating the **Metamorphic Origin of Mica Schist,** and the difference between stratification-foliation and cleavage-foliation. *H. C. Sorby.*

"Ripple drift" in slate rocks in which the cleavage cuts the stratification at a considerable angle.

"Ripple drift" in contorted and highly metamorphosed mica schist, thus proving the original stratified nature of the rock.

Mica schist with foliation in the plane of stratification, being rock metamorphosed before being compressed.

Mica schist with foliation in the plane of cleavage, developed by compression, before the work was metamorphosed.

3295. Microscopical Photographs of sections of iron and steel. *H. C. Sorby.*

The above were photographed by means of strong surface illumination, and show structures due to the arrangement of crystals of iron combined with a varying amount of carbon, of portions of slag, and of crystalline plates of graphite. Note the contrast between the structure of cast iron, cast steel, and meteoric iron, although all have solidified from fusion.

3296. Microscopical Sections of iron and steel. *H. C. Sorby.*

The above were prepared by very carefully grinding down and polishing the surface so as to avoid all such burnishing action as would alter the form or structure of the ultimate crystalline particles. The whole section is then placed in very dilute nitric acid, and carefully examined in water under the microscope, time after time, until the irregular action of the acid on the different constituents has advanced so far as to show the general structure to the greatest advantage. The surface is then well washed, dried, and gently wiped, and finally protected by a thin glass cover cemented down by Canada balsam.

3297. Working Model illustrating the Formation of "False Bedding" in Stratified Rocks. *H. C. Sorby.*

The drifting action of the current of water is represented by the screw, which carries forward the sand until it falls down and accumulates on the slope at the angle of rest. The larger fragments roll to the bottom, and the fine particles are sorted or not into thin or thicker bands according as the screw is moved in an irregular or regular manner, just as occurs when a current moves with varying velocity. The arrangement of the materials thus produced is in all respects similar to what is so often seen in certain beds of stratified rocks.

3298. Microscopical Sections of Shells and Rocks. *H. C. Sorby.*

These are prepared by grinding down one side to a perfectly flat and smooth surface, which is then fixed to a glass with Canada balsam. After this, the other side is ground down, first with emery and at last on a very hard piece of water of Ayr stone, so as to leave a thin portion of the rock in a perfectly undisturbed condition attached to the glass, with a smooth and almost polished surface. According to the nature of the rock, the thickness of such sections should vary from about $\frac{1}{100}$ to $\frac{1}{1000}$th of an inch. Thin glass is then mounted over the whole with Canada balsam. As examples of rocks presenting special difficulties, attention may be drawn to the sections of soft chalk, and of slate and mica schist, cut perpendicularly to the cleavage or foliation.

3299. Lithographed Plates, illustrating the Microscopical Structure of Limestones. *H. C. Sorby.*

These show structure due to larger or smaller fragments of organic bodies or grains of sand, and to the more or less complete development of crystals formed either during or after the deposition of rock.

3300. Working Model, illustrating the Movement of Waves in forming ripple marks. *H. C. Sorby.*

The model shows the movement of the particles at the surface and at the bottom of a wave which has advanced from deep to shallow water, so as to give rise to ripple marks. At the surface the water moves nearly in circles, which in the model is represented by the white discs attached to arms connected with each alternate wheel. At the bottom the water moves forwards and backwards, drifting the sand in the line of the movement of the wave when its crest is passing, and backwards when the trough is passing. In the model this movement is produced by the action of small eccentric wheels on pieces of brass fixed at one end and carrying white discs at the other.

3300a. Specimens relating to the exhibitor's researches on synthetical and experimental Geology.

1. Minerals formed at about 400° by superheated water (1860).
2. Product of the reactions of vapours.

3. Contemporaneous minerals, produced by the action of hot springs (1858 to 1876).

4. Transformation of terrestrial rock into meteoric rock (1866).

5. Imitation, by experiment made with native magneto-polar platina (1875).

6. Experiments upon the possibility of capillary infiltration through the pores of rocks, notwithstanding the resistance of a high steam pressure (1861).

7. Experiments upon the schistose properties of rocks, geological deductions (1860 to 1876).

M. Daubrée, Director, School of Mines, Paris.

3252p. Stand and Glass Cover, with eight specimens of minerals of contemporaneous formation.

M. Daubrée, Director, School of Mines, Paris.

3252q. Stand and Glass Cover, with four specimens of minerals formed in water heated to 400°.

M. Daubrée, Director, School of Mines, Paris.

3252t. Stand, with three tubes of iron burst by expansion of steam in the above experiments.

M. Daubrée, Director, School of Mines, Paris.

3252r. Apparatus to demonstrate the possibility of capillary infiltration in the pores of rocks.

M. Daubrée, Director, School of Mines, Paris.

3252s. Specimen, illustrating the transformation of terrestrial rocks into meteoric stones.

M. Daubrée, Director, School of Mines, Paris.

3252u. Three Specimens of Earth, illustrating the schistosity of rocks. *M. Daubrée, Director, School of Mines, Paris.*

3252v. Small Stand and Glass Shade, with three specimens of magneto-polar platinum (contained in glass covered cardboard case). *M. Daubrée, Director, School of Mines, Paris.*

3252w. Bound Volume, "Programme des Cours de l'Ecole des Mines."

M. Daubrée, Director, School of Mines, Paris.

3252x. Bound Volume, "Institution et But de l'Ecole Programme de l'Admission," etc.

M. Daubrée, Director, School of Mines, Paris.

3307. Sections of Typical Rocks (30 specimens), a selection of Prof. J. Roth, Berlin; with a commentary by Prof. H. Rosenbusch, Strasburg. *R. Fuess, Berlin.*

3308. Sections of Typical Rocks (30 specimens), with a commentary; a selection by Prof. F. Zirkel, Leipsic.

R. Fuess, Berlin.

3309. Sections of Typical Basalts (30 specimens), a selection by Prof. H. Möhl, Cassel; with a commentary.
R. Fuess, Berlin.

3310. Sections of Rock-forming Minerals (30 specimens), a selection by Prof. H. Rosenbusch, Strasburg; with a commentary. *R. Fuess, Berlin.*

3311. Sections of the Rocks of the Kaiserstuhl (30 specimens), a selection by Prof. H. Rosenbusch, Strasburg.
R. Fuess, Berlin.

3312. Sections of the Eruptive Rocks of Hungary and Servia (30 specimens), a selection by Prof. Szabo, Budapest; with a commentary. *R. Fuess, Berlin.*

3313. Sections of Typical Rocks (30 specimens), a selection by Prof. F. Zirkel, Leipsic; with a commentary.
R. Fuess, Berlin.

3314. Sections of the most Characteristic Rocks of the Huronian iron region, Lake Superior, U.S.A. (30 specimens), a selection by Major T. B. Brooks, Wisconsin Geological Survey, and microscopically examined by Dr. Wichmann, Leipsic.
R. Fuess, Berlin.

3315. Collection of Thin Sections of all the rocks occurring in the Fichtelgebirge.
Geological Survey of Bavaria (*Dr. Gümbel*).

The collection of thin sections illustrates the method of collecting and examining, large numbers of slices from the same rock and locality being prepared. The accompanying plate shows sections of a few of the most important of these rocks magnified and printed in colours.

3316. Pictures of the most important of these **Rocks,** as drawn from sections under the microscope.
Geological Survey of Bavaria (*Dr. Gümbel*).

3317. Collection of Hand Specimens of Typical Tertiary Basalts and altered enclosures (68 specimens), illustrated by one hundred thin sections.
Mineralogical and Geological Cabinet of the School of Industry, Cassel (*Dr. H Möhl*).

The classification of the Basalts is that begun by Prof. F. Zirkel, and extended by the exhibitor, as illustrated in Paper No. I. Special descriptions of these rocks and their structure will be found in the Papers II.–VII., the figures being contained in Paper X.

3318. Collection of Hand Specimens of Typical Phonolites and nearly related Andesites (38 specimens), illustrated by seventy thin sections.
Mineralogical and Geological Cabinet of the School of Industry, Cassel (*Dr. H. Möhl*).

The classification of the Phonolites by the exhibitor is contained in Paper No. IX., the felspar phonolites of other authors being omitted as approaching more to the trachytes. Drawings and descriptions of normal types are found in Paper No. X., with the original plates G and H.

3319. Collection of Hand Specimens of Typical Basaltites (Melaphyre, Palatinite, Minette, Kersanton and Kersantite), also Porphyrite (48 specimens), illustrated by ninety thin sections.
Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

For reasons in favour of adopting the name Basaltite, *see* Paper No. 8, 1st and 2nd part. The descriptions of two so-called minettes will be found in Paper No. VII., 3rd part.

3320. Thirteen Papers relating to the above rocks and sections, with drawings, also ten coloured plates of drawings of thin sections (amongst them six original plates).

Original water-colour drawings.
Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

3319a. Collection of Specimens of Rocks of the Canary Islands. *Don Salvador Calderon, Madrid.*

These specimens are accompanied by a memoir by Señor Calderon, on the rocks of the Canary Islands, entitled "Resiña de las rocas de la isla volcanica Grau Canaria." 4° Madrid, 1876.

3321. Thin Sections of typical rocks in a box (90 specimens).
Voigt and Hochgesang, Göttingen (Gust. Voigt).

Contains rocks selected according to F. Zirkel's "Microscopical Characters of Minerals and Rocks."

3322. Thin Sections of typical rocks in a box (20 specimens).
Voigt and Hochgesang, Göttingen (Gust. Voigt).

Collected by Dr. v. Seebach, and described by Dr. F. Zirkel, Leipzic.

3323. Series of the most characteristic Porphyries of Silesia, with thin sections of the same, in a case.
University of Breslau (Prof. A. von Lasaulx).

3324. Collection of Thin Sections of the rocks of Saxony.
Royal Saxon Mining Academy, Freiberg.

3266. Maps, illustrative of theories of relative directions of lodes, joints, mountain chains, coast lines, limits of geological formations and rivers. *Jos. P. O'Reilly.*

Map of Europe (geographical); two base lines, viz., Algerian coast and Syrian coast lines.

Map of Spain (Francisco Cuillo's geographical); base line taken from the map of Europe. (Compare with de Verneuil's map for correspondence of geographical and geological lines of direction.)

Alpine Club Map of Switzerland; two base lines from globe, east coast of Sardinia and south-east coast of Red Sea.

Jukes's geological map of Ireland; base line, eastern coast of Adriatic.

The base lines are portions of great circles having the directions of, and passing along, the coast lines indicated, and have been transferred from the globe.

3326. Globe mounted for the study and demonstration of the angular relations of directions presented by lodes, dykes, lines of dislocation, mountain chains, coast lines, and river valleys.

Jos. P. O'Reilly.

This globe allows of the tracing of great circles through given points, with great facility and rapidity. These great circles can be transferred to maps, and serve as bases of comparison for the lode systems of mining districts, and in general for all geological lines of direction.

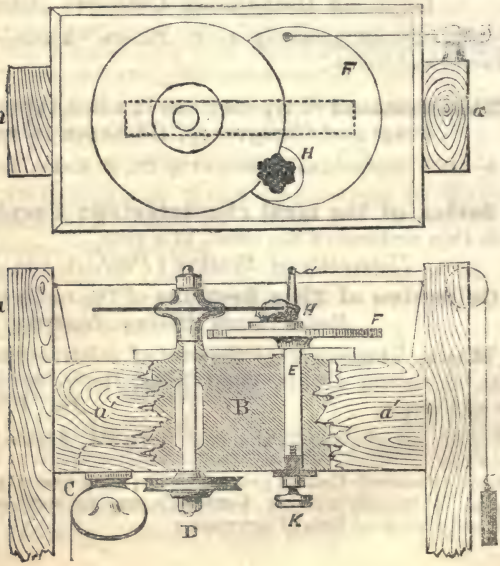
The above was designed by the exhibitor in 1874, and used for public lectures. A similarly mounted globe was shown in Paris at the Geographical Exhibition of 1875, by M. Chancourtois.

3327. Portable Apparatus, for preparing Sections of rocks, minerals, fossils, &c., for microscopic examination.

F. G. Cuttell.

3328. Specimens of Sections prepared with the above machine. *F. G. Cuttell.*

3328. Lapidary Apparatus for slitting, grinding, and polishing rocks, pebbles, fossils, &c., especially adapted for the



preparation of thin sections of rock or other hard material for microscopical examination. Designed by the exhibitor, and manufactured by Messrs. Cotton & Johnson, Soho. *James B. Jordan.*

The machine consists of a mahogany, oak, or beech framework (*a a*), similar to that of an ordinary turning lathe, and is supplied with crank, fly-wheel, and treadle, occupying a floor space of 2 ft. 2 in. by 20 in. To the bed of this frame is fitted an iron casting (B), bored to receive two spindles, viz.:—a vertical spindle (D), which carries the slitting disc, grinding laps, &c., and another spindle (E), to which is fixed a horizontal plate (F), carrying on its surface a cup containing cement, in which the material to be cut is imbedded, and which is retained and uniformly pressed against the slitting disc by means of a cord attached to the plate, which, passing over a pulley having a suspended weight (G), gives a constant and regular pressure to the plate containing the specimen. There is also a convenient screw arrangement (K) by which this plate can be accurately adjusted for the purpose of regulating the thickness of the slice. The slitting disc and laps are made to revolve, at the rate of about 500 revolutions per minute, by means of a treadle used in the ordinary way.

3329. Apparatus for the preparation of rock sections, and plates of crystals for examination in polarised light.

R. Fuess, Berlin.

3330. Apparatus for the preparation of **Thin Microscopic Sections** of rocks and minerals :—

1. Cutting apparatus.
2. Grinding and polishing apparatus.

Christ. Weber, Eisenach.

3353a. Ceteosaurus Oxoniensis.

Left femur.
Dorsal vertebra, 2 views.
Left humerus.
Ilium, 2 views.

Dr. Acland, F.R.S., on behalf of the Radcliffe Trustees.

3353b. Megalosaurus Bucklandi.

Upper jaw.
Lower jaw.
Scapula.
Pubis.
Right tibia.
Ilium.
Caracoid.
Rib.
Ischium, 2 views.
Sacrum.

Dr. Acland, F.R.S., on behalf of the Radcliffe Trustees.

3354. Plates of British Fossils, from the annual volumes of the Palæontographical Society. *The Rev. Thomas Wiltshire.*

Illustrating :—

Pleistocene Mammalia (skull of Felis spelæa).
Upper Greensand Urchins (Caratomus rostratus).
Lower Greensand Urchins (Trematopygus faringdonensis).
Wealden Reptilia (Radius and Ulna of Iguanodon Mantelli).
Purbeck Mammalia (Teeth and Jaws of Stylodon, Leptocladus, Bolodon, &c.).
Oxford Clay Belemnites (Belemnites Puzosianus ; B. porrectus).
Inferior Oolite Corals (Thecosmilia Wrighti ; T. Flemingi).
„ „ Trigoniæ (Trigonia signata ; T. Moretoni).
Liassic Corals (Astrocænia gibbosa, Helistræa Moorei, &c.).
„ Starfish (Ophioderma Gaveyi ; O. Egertoni).
Carboniferous Flora (Halonia regularis).
Devonian Crustacea (Stylonurus Powriei ; Cheirurus articulatus).
„ Brachiopoda (Spirifera disjuncta, Spiriferina cristata).
„ Fish (Cephalaspis Lyelli ; C. Murchisonii).
Silurian Trilobites (Phacops, Amphion, Asaphus).
„ Eurypterida (Slimonia acuminata, Pterygotus bilobus).

3355. Collection of Fossil Plants, proving the existence of the elements of recent flora in that of the Tertiary period, comprising examples of the elementary forms of salt and fresh water flora, and of the various continents, including Australia.

Fossil plants from various localities in the Tertiary formation are also exhibited, exemplifying the origin of our recent local flora from ancient types.

This is shown by coloured tickets attached to the specimens.

The change of the fossil *Castanea atavia* into the recent *Castanea vesca* is also illustrated.

Prof. Dr. Constantin Baron von Ettingshausen, Graz.

I.—THE TERTIARY FLORAS, ELEMENTS IN GENERAL.

A.—Elements of the Flora of Salt Water.

Caulerpa pyramidalis, *Sternb.* Wiener Sandstein.
Caulerpa, *sp. n.* Wiener Sandstein.
Sphaerococcites, *sp. n.* Podsused.
Chondrites furcatus, *Brongn.* Wiener Sandstein.
Chondrites intricatus, *Brongn.* Wiener Sandstein.
Cystoseira communis, *Ung.* Radoboj.
Zostera Ungeri, *Ett.* Radoboj.

B.—Elements of the Flora of Fresh Water.

Confervites bilinicus, *Ung.* Schoenegg.
Chara Meriani, *A. Braun.* Savine.
Typha latissima, *A. Braun.* Schoenegg, Savine, Leoben.
Sparganium, *sp. n.* Schoenegg.
Najadopsis lucens, *Ett.* Schoenegg.
Ceratophyllum, *sp. n.* Schoenegg.
Anoectomeria Brongniarti, *Sap.* Leoben, Podsused, Haering.
Nelumbium Buchii, *Ett.* Leoben, Kutschlin.

C.—Elements of the Flora of Australia.

Casuarina Haidingeri, *Ett.* Leoben, Haering, Schoenegg.
Leptomeria Benthami, *Ett.* (Styriaca, *Ett. MS.*). Schoenegg.
Leptomeria gracilis, *Ett.* Haering.
Santalum, *sp. n.* Schoenegg.
Santalum osyrinum, *Ett.* Haering.
Hakea, *sp. n.* Parschlug.
Hakea macroptera, *Ett.* Sagor, Schoenegg.
Banksia longifolia, *Ett.* Savine.
Banksia haeringiana, *Ett.* Haering.
Banksia Ungeri, *Ett.* Monte Promina.
Banksia Haidingeri, *Ett.* Trifail.
Dryandra acutiloba, *Ett.* Bilin.
Eucalyptus oceanica, *Ung.* Sotzka.
Eucalyptus haeringiana, *Ett.* Haering.

D.—Elements of the Asiatic Floras.

Glyptostrobus europaeus, *Heer.* Schoenegg.
Planera Ungeri, *Ett.* Parschlug.
Ficus Deschmanni, *Ett.* Savine.
Ficus tenuinervis, *Ett.* Islaak.
Iuglans costata, *Ung.* Putschirn.
Iuglans parschlugiana, *Ung.* Parschlug.
Engelhardtia Brongniarti, *Sap.* Radoboj, Savine, Leoben.
Cinnamomum polymorphum, *A. Braun.* Savine, Promina, Schoenegg.
Nerium, *sp. n.* Fohnsdorf.
Ailanthus, *sp. n.* Schoenegg.

E.—Elements of the American Floras.

Taxodium distichum miocenicum. Bilin.
Libocedrus, *sp. n.* Leoben.
Sequoia Sternbergii, *Goepp.* Haering.
Sequoia Couttsiæ, *Heer.* Savine, Bilin.
Sequoia Tournalii, *Brongn.* Haering.
Sequoia Langsdorfii, *Brongn.* Leoben.
Pinus Palaeostrobus, *Ett.* Leoben.
Myrica lignitum, *Ung.* Parschlug, Schoenegg.
Myrica salicina, *Ung.* Radoboj.
Quercus daphnes, *Ung.* Parschlug.
Fagus Feroniæ, *Ung.* Leoben, Bilin.
Ulmus Braunii, *Heer.* Parschlug, Schoenegg.
Populus latior, *A. Braun.* Parschlug, Leoben.
Liquidambar europaeum, *A. Braun.* Parschlug.
Ficus arcinervis, *Heer.* Savine.
Andromeda protogaea, *Ung.* Savine.
Acer trilobatum, *A. Braun.* Bilin, Schoenegg, Leoben.
Acer megalopteryx, *Ung.* Radoboj.
Tetrapteris, *sp. n.* Savine.
Ternstroemia radobojana, *Ett.* Radoboj.
Carya bilinica, *Ung.* Bilin.
Robinia Hesperidum, *Ung.* Parschlug, Fohnsdorf.

F.—Elements of the African Floras.

Widdringtonia Ungeri, *Endl.* Parschlug.
Callitris Brongniarti, *Endl.* Radoboj, Leoben, Podsused.
Myrica subæthiopica, *Ett.* Parschlug.
Pterocelastrus, *sp. n.* Parschlug.
Celastrus oxyphyllus, *Ung.* Parschlug.
Celastrus Aeoli, *Ett.* Schoenegg.
Celastrus, *sp. n.* Parschlug.
Celastrus deperdidus, *Ett.* Parschlug.
Rhus cuneolata, *Ung.* Parschlug.
Rhus, *sp. n.* Parschlug.

G.—Elements of the European Flora.

Pinus Laricio, *Poir.* Leoben Schoenegg, Podsused.
Pinus Palæo-abies, *Ett.* Sagor.
Alnus Kefersteinii, *Goepp.* Schoenegg, Leoben.
Alnus gracilis, *Ung.* Leoben.
Quercus mediterranea, *Ung.* Parlug.
Fagus deucalionis, *Ung.* Parschlug, Putschirn.
Ulmus Bronnii, *Ung.* Leoben, Bilin.
Acer decipiens, *A. Braun.* Parschlug, Leoben.

II.—THE MIXTURE OF THE TERTIARY ELEMENTS OF THE FLORAS.

1. *Haering in Tyrol.*

Xylomites Zizyphi, *Ett.*
Puccinites lanceolatus, *Ett.*
Casuarina Haidingeri, *Ett.* (Australian form.)
Elaeodendron degener, *Ett.* (Asiatic form.)
Callitris Brongniarti, *Endl.* (African form.)
Sequoia Sternbergii, *Goepp.* (American form.)
Sequoia Sternbergii, *Goepp.*
Sabal major, *Ung.* (American form.)
Persoonia daphnes, *Ett.* (Australian form.)
Sequoia Sternbergii, *Goepp.* (American form.)
Santalum salicinum, *Ett.* (Australian form.)
Sequoia Tournalii, *Brongn.* (American form.)
Santalum salicinum, *Ett.* (Australian form.)
Sequoia Tournalii, *Brongn.* (American form.)
Casuarina Sotzkiana, *Ett.* (Australian form.)
Sequoia Couttsiae, *Heer.* (American form.)
Sabal major, *Ung.* (American form.)
Persoonia daphnes, *Ett.* (Australian form.)
Celastrus protogaeus, *Ett.* (African form.)
Banksia Ungeri, *Ett.* (Australian form.)
Banksia haeringiana, *Ett.* (Australian form.)
Rhus prisca, *Ett.* (African form.)
Dryandra Brongniarti, *Ett.* (Australian form.)
Zizyphus Ungeri, *Heer.* (Asiatic form.)
Ceratopetalum haeringianum, *Ett.* (Australian form).
Cassia ambigua, *Ung.* (American form.)
Persoonia daphnes, *Ett.* (Australian form.)
Dodonaea salicites, *Ett.* (Australian form.)
Zizyphus Ungeri, *Heer.* (Asiatic form.)
Embothrites leptospermos, *Ett.* (Australian form.)
Zizyphus Ungeri, *Heer.* (Asiatic form.)
Caesalpinia Haidingeri, *Ett.* (Asiatic form.)
Eucalyptus haeringiana, *Ett.* (Australian form.)
Cassia pseudoglandulosa, *Ett.* (Asiatic form.)

2. *Sotzka in Styria.*

Davallia Haidingeri, *Ett.* (Canarian form.)
Sequoia Sternbergii, *Goepp.* (American form.)
Betula eocenica, *Ett.* (European form.)
Ficus apocynoides, *Ett.* (American form.)

Ficus Laurogene, *Ett.* (American form.)
Banksia Ungeri, *Ett.* (Australian form.)
Notelaea eocenica, *Ett.* (Australian form.)
Apocynophyllum ochrosioides, *Ett.*
Sapotacites minor, *Ett.*
Ceratopetalum haeringianum, *Ett.* (Australian form.)
Hiraea Ungeri, *Ett.* (American form.)
Cupania juglandina, *Ett.* (Australian form.)
Acer sotzkianum, *Ung.* (European form.)
Zizyphus Druidum, *Ung.* (Asiatic form.)
Engelhardtia sotzkiana, *Ett.* (Asiatic form.)
Andromeda protogaea, *Ung.* (American form.)
Callistemophyllum diosmoides, *Ett.* (Australian form.)
Getonia macroptera, *Ung.* (Asiatic form.)
Callistemon eocenicum, *Ett.* (Australian form.)
Cassia Phaseolites, *Ung.* (American form.)
Davallia Haidingeri, *Ett.* (Canarian form.)
Acacia caesalpiniaefolia, *Ett.* (Australian form.)

3. *Monte Promina in Dalmatia.*

Sphenopteris eocenica, *Ett.*
Cinnamomum lanceolatum, *Ung.* (Asiatic form.)
Cassia Phaseolites, *Ung.* (American form.)
Cinnamomum polymorphum, *Ung.* Asiatic form.)
Sequoia Sternbergii, *Goepp.* (American form.)
Bambusium sepultum, *Ung.* (Asiatic form.)
Apocynophyllum plumeriaefolium, *Ett.* (Tropical form.)
Rhamnus Eridani, *Ung.* (American form.)

4. *Kutschlin in Bohemia.*

Libocedrus salicornioides, *Endl.* (American form.)
Sequoia Sternbergii, *Goepp.* (American form.)
Cinnamomum lanceolatum, *Ung.* (Asiatic form.)
Celastrus elaenus, *Ung.* (American form.)
Engelhardtia Brongniarti, *Sap.* (Asiatic form.)

5. *Sagor in Carniola.*

Sequoia Sternbergii, *Goepp.* (American form.)
Zostera Ungeri, *Ett.* (Salt water form.)
Quercus daphnes, *Ung.* (American form.)
Ficus bumeliaefolia, *Ett.* (American form.)
Carpinus grandis, *Ung.* (European form.)
Banksia longifolia, *Ett.* (Australian form.)
Dryandra sagoriana, *Ett.* (Australian form.)
Cinnamomum polymorphum, *A. Braun.* (Asiatic form.)
Cinnamomum lanceolatum, *Ung.* (Asiatic form.)
Andromeda protogaea, *Ung.* (American form.)
Engelhardtia Brongniarti, *Sap.* (Asiatic form.)

6. *Savine in Carniola.*

Sphaeria Suessii, *Ett.*
Chara Langeri, *Ett.*
Hypnum sagorianum, *Ett.*
Glyptostrobus europaeus, *Heer.* (Asiatic form.)
Sequoia Langsdorfii, *Brongn.* (American form.)
Sequoia Couttsiae, *Heer.* (American form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Ostrya Atlantidis, *Ung.* (American form.)
Ficus bumeliaefolia, *Ett.* (American form.)
Ficus lanceolato-acuminata, *Ett.* (Tropical form.)
Pisonia eocenica, *Ett.* (Asiatic form.)
Cinnamomum lanceolatum, *Ung.* (Asiatic form.)
Laurus stenophylla, *Ett.* (American form.)
Banksia longifolia, *Ett.* (Australian form.)
Neritinium majus, *Ung.* (Tropical form.)
Apocynophyllum Reussii, *Ett.* (Tropical form.)
Andromeda protogaea, *Ung.* (American form.)
Tetrapteris sagoriana, *Ett.* (American form.)
Celastrus deperditus, *Ett.* (African form.)
Celastrus Hippolyti, *Ett.* (African form.)
Berthemia, *sp. n.* (American form.)
Engelhardtia Brongniarti, *Sap.* (Asiatic form.)
Eucalyptus oceanica, *Ung.* (Asiatic form.)
Sophora europaea, *Ung.* (Asiatic form.)
Cassia Phaseolites, *Ung.* (American form.)

7. *Fohnsdorf in Styria.*

Proteoides lanceolatus, *Ett.* (African form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Banksia, *sp.* (Australian form.)
Enteromorpha stagnalis, *Heer.* (Fresh-water form.)
Glyptostrobus europaeus, *Heer.* (Asiatic form.)
Sequoia Langsdorfii, *Brongn.* (American form.)
Pinus rigios, *Ung.* (American form.)
Alnus Kefersteinii, *Goepp.* (European form.)
Quercus Drymeja, *Ung.* (American form.)
Fagus Feroniae, *Ung.* (American form.)
Lomatia angustifolia, *Ett.* (Australian form.)
Banksia longifolia, *Ett.* (Australian form.)
Banksia Ungeri, *Ett.* (Australian form.)
Cinnamomum Scheuchzeri, *Heer.* (Asiatic form.)
Carya bilinica, *Ung.* (American form.)
Cinnamomum polymorphum, *A. Braun.* (Asiatic form.)
Nerium, *sp. n.* (Asiatic form.)
Acer trilobatum, *A. Braun.* (American form.)
Celastrus deperdidus, *Ett.* (African form.)
Cassia ambigua, *Ung.* (American form.)
Sophora europaea, *Ung.* (Asiatic form.)
Acacia parschlugiana, *Ung.* (American form.)

8. *Eibiswald in Styria.*

Glyptostrobus europaeus. (Asiatic form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Phoenicites, *sp. n.* (Trop. form.)
Ficus tiliaefolia, *Ung.* (American form.)
Embothrites borealis, *Ung.* (Australian form.)
Lomatia angustifolia, *Ett.* (Australian form.)
Callistemophyllum, *sp. n.* (Australian form.)

9. *Radoboj in Croatia.*

Cystoseira communis, *Ung.* (Salt-water form.)
Cystoseira affinis, *Ung.* (Salt-water form.)
Woodwardia Roessneriana, *Ung.* (European form.)
Pteris firma, *Ett.* (African form.)
Libocedrus salicornioides, *Endl.* (American form.)
Callitris Brongniarti, *Endl.* (African form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Zostera Ungeri, *Ett.* (Salt-water form.)
Smilax grandifolia, *Ung.*
Myrica deperdita, *Ung.* (American form.)
Ulmus prisca, *Ung.* (European form.)
Laurelia rediviva, *Ung.* (American form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Zostera Ungeri, *Ett.* (Salt-water form.)
Pisonia radobojana, *Ett.* (American form.)
Embothrites sotzkianus, *Ung.* (Australian form.)
Cinnamomum polymorphum, *A. Braun.* (Asiatic form.)
Fraxinus primigenia, *Ung.* (European form.)
Diospyros bilinica, *Ett.* (Asiatic form.)
Olea Osiris, *Ung.* (African form.)
Weinmannia europaea, *Ett.* (American form.)
Ceratopetalum radobojanum, *Ett.* (Australian form.)
Cissus radobojensis, *Ett.* (American form.)
Acer trilobatum, *A. Braun.* (American form.)
Acer campylopteryx, *Ung.* (American form.)
Engelhardtia Brongniarti, *Sap.* (Asiatic form.)
Embothrites borealis, *Ung.* (Australian form.)
Zostera Ungeri, *Ett.* (Salt-water form.)
Engelhardtia Brongniarti, *Sap.* (Asiatic form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Getonia petraeaeformis, *Ung.* (Asiatic form.)
Dalbergia sotzkiana, *Ung.* (Asiatic form.)
Rhynchosia Isidis, *Ung.* (African form.)
Rhus Pyrrhae, *Ung.* (American form.)
Rhus obovata, *Ett.* (African form.)

10. *Podsused in Croatia.*

Cystoseira communis, *Ung.* (Salt-water form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Pinus Laricio, *Poir.* (European form.)
Myrica salicina, *Ung.* (American form.)
Quercus Lonchitis, *Ung.* (American form.)
Pisonia eocenica, *Ett.* (Asiatic form.)
Laurus tetrantheroides, *Ett.* (American form.)
Sapindus Pythii, *Ung.* (American form.)

11. *Bilin in Bohemia.*

Glyptostrobus europaeus, *Heer.* (Asiatic form.)
Taxodium distichum, *Mioc.* (American form.)
Sequoia Couttsiae, *Heer.* (American form.)
Alnus Kefersteinii, *Goepp.* (European form.)
Fagus Feroniae, *Ung.* (American form.)
Ulmus plurinervia, *Ung.* (European form.)
Cinnamomum Rossmaessleri, *Heer.* (Asiatic form.)
Acer trilobatum, *A. Braun.* (American form.)
Carya bilinica, *Ung.* (American form.)

12. *Leoben in Styria.*

Sphaeria Dryadum, *Ett.*
Dothidea, *sp. n.*
Xylomites Lonchitidis, *Ett.*
Xylomites, *sp. n.*
Rhytisma Geinitzii, *Ett.*
Glyptostrobus europaeus, *Heer.* (Asiatic form.)
Sequoia Couttsiae, *Heer.* (American form.)
Pinus Laricio, *Poir.* (European form.)
Alnus Kefersteinii, *Goepp.* (European form.)
Castanea atavia, *Ung.* (European form.)
Alnus gracilis, *Ung.* (European form.)
Fagus Feroniae, *Ung.* (American form.)
Quercus Lonchitis. (American form.)
Populus Geinitzii, *Ett.* (American form.)
Urtica miocenica, *Ett.* (American form.)
Ficus Deschmanni, *Ett.* (Asiatic form.)
Ficus Iynx, *Ung.* (Asiatic form.)
Cinnamomum polymorphum. A. Br. (Asiatic form.)
Cinnamomum Scheuchzeri. (Asiatic form.)
Cinnamomum lanceolatum, *Ung.* (Asiatic form.)
Nectandra arcinervia, *Ett.* (American form.)
Santalum microphyllum. *Ett.* (Australian form.)
Banksia, *sp. n.* (Australian form.)
Glyptostrobus europaeus. (Asiatic form.)
Apocynophyllum haeringianum, *Ett.* (Tropical form.)
Evonymus, *sp. n.* (Asiatic form.)
Juglans Reussii, *Ett.* (Asiatic form.)
Cassia Zephyri, *Ett.* (American form.)
Cassia Feroniae, *Ett.* (Asiatic form.)
Cassia leptodictyon, *Ett.* (American form.)

13. *Schoenegg in Styria.*

Blechnum Goepperti, *Ett.* (American form.)
Phegopteris stiriaca, *Ung.* (American form.)
Glyptostrobus europaeus. (Asiatic form.)
Fagus Feroniae, *Ung.* (American form.)
Ulmus Braunii, *Heer.* (American form.)
Juglans parschlugiana, *Ung.* (Asiatic form.)
Alnus Kefersteinii, *Goepp.* (European form.)
Glyptostrobus europaeus. (Asiatic form.)
Santalum, *sp. n.* (Australian form.)
Myrica lignitum, *Ung.* (American form.)
Pinus Palaeo-taeda, *Ett.* (American form.)
Sequoia Langsdorfii, *Brongn.* (American form.)
Typha latissima, *A. Br.* (European form.)
Ceratophyllum, *sp. n.* (European form.)
Celastrus pachyphyllus, *Ett.* (African form.)
Alnus Kefersteinii, *Goepp.* (European form.)
Betula grandifolia, *Ett.* (European form.)
Ficus daphnogenes, *Ett.* (Asiatic form.)
Laurus primigenia, *Ung.* (European form.)
Glyptostrobus europaeus. (Asiatic form.)
Quercus mediterranea, *Ung.* (European form.)
Ulmus Bronnii, *Ung.* (European form.)
Myrica lignitum, *Ung.* (American form.)
Callistemophyllum melaleucaeforme, *Ett.* (Australian form.)

Celastrus pachyphyllus, *Ett.* (African form.)
Glyptostrobus europaeus. (Asiatic form.)
Cinnamomum polymorphum, *A Braun.* (Asiatic form.)
Cinnamomum Scheuchzeri, *Heer.* (Asiatic form.)
Santalum, *sp. n.* (Australian form.)
Myrica, *sp. n.* (American form.)
Leptomeria Benthami, *Ett.* (Australian form.)
Celastrus, *sp. n.* (African form.)
Banksia, *sp.* (Australian form.)
Pomaderris, *sp. n.* (Australian form.)
Glyptostrobus europaeus. (Asiatic form.)
Fagus Feroniæ, *Ung.* (American form.)
Myrica lignicum, *Ung.* (American form.)
Banksia Ungeri, *Ett.* (Australian form.)
Laurus Swoszowiciana, *Ung.* (European form.)

Fraxinus, *sp. n.* (European form.)
Sapotacites minor, *Ett.* (Tropical form.)
Acer trilobatum, *A. Braun.* (American form.)
Sapindus Pythii, *Ung.* (American form.)
Pinus Laricio, *Poir.* (European form.)
Quercus Lonchitis, *Ung.* (American form.)
Glyptostrobus europaeus. (Asiatic form.)
Celastrus Acherontis, *Ett.* (African form.)
Engelhardtia Brongniarti, *Sap.* (Asiatic form.)
Pterocelastrus Oreonis, *Ett.* (African form.)
Eucalyptus oceanica, *Ung.* (Australian form.)
Podogonium Knorrii, *Heer.*
Cassia Phaseolites, *Ung.* (American form.)
Santalum salicinum, *Ett.* (Australian form.)

14. *Parschlug in Styria.*

Sphaeria Braunii, *Heer.*
Xylomites granulifer, *Ett.*
Xylomites liquidambaris, *Ett.*
Hypnum Schimperi, *Ung.* (European form.)
Glyptostrobus europaeus. (Asiatic form.)
Podogonium Knorrii, *Heer.*
Pinus Goethana, *Ung.* (American form.)
Widdringtonia Ungeri. *Endl.* (African form.)
Sapindus falcifolius, *A. Braun.* (American form.)
Myrica lignitum, *Ung.* (American form.)
Widdringtonia Ungeri, (African form.)
Quercus daphnes, *Ung.* (American form.)
Planera Ungeri, *Ett.* (Asiatic form.)
Planera Ungeri, *Ett.* (Asiatic form.)
Macreightia germanica, *Heer.* (American form.)

Ulmus Braunii, *Heer.* (American form.)
Populus latior. *A. Braun.* (American form.)
Liquidambar europaeum, *A. Braun.* (American form.)
Banksia, *sp.* (Australian form.)
Ilex aspera, *Ett.* (American form.)
Fraxinus primigenia, *Ung.* (European form.)
Sapotacites minor, *Ett.* (Tropical form.)
Ledum limnophilum, *Ung.* (American form.)
Vaccinium acheronticum, *Ung.* (American form.)
Acer trilobatum, *A. Braun.* (American form.)
Sapindus Pythii, *Ung.* (American form.)
Celastrus, *sp. n.* (African form.)
Sapindus, *sp. n.* (American form.)
Pterocelastrus, *sp. n.* (African form.)

Elaeodendron, *sp. n.* (African form.)
Ramnus aizoon, *Ung.* (American form.)
Myrica lignitum, *Ung.* (American form.)
Vaccinium vitis Iapeti, *Ung.* (European form.)
Juglans parschlugiana, *Ung.* (Asiatic form.)
Myrica lignitum. (American form.)
Ilex stenophylla, *Ung.* (American form.)
Quercus mediterranea, *Ung.* (European form.)
Myrica deperdita, *Ung.* (American form.)
Quercus serra, *Ung.* (American form.)
Planera Ungeri, *Ett.* (Asiatic form.)
Myrica lignitum, *Ung.* (American form.)
Vaccinium vitis Iapeti, *Ung.* (American form.)
Juglans parschlugiana. (Asiatic form.)
Rhus, *sp. n.* (American form.)
Rhus elaeodendroides, *Ung.* (African form.)
Glyptostrobus europaeus. (Asiatic form.)
Rhus retine, *Ung.* (American form.)
Rhus zanthoxyloides, *Ung.* (American form.)
Populus latior, *A. Braun.* (American form.)
Quercus Lonchitis, *Ung.* (American form.)
Quercus mediterranea, *Ung.* (European form.)
Myrica lignitum, *Ung.* (American form.)
Rosa Penelopes, *Ung.*
Physolobium orbiculare, *Ung.* (Australian form.)
Physolobium microphyllum, *Ett.* (Australian form.)
Glycyrrhiza Blandusiae, *Ung.* (European form.)
Cassia Phaseolites, *Ung.* (American form.)
Acacia parschlugiana, *Ung.* (American form.)

The above are original specimens collected in Styria, Carniola, Croatia, Dalmatia, the Tyrol, Hungary, and Bohemia.

The recent plants bearing closest analogy to the fossil plants are shown for comparison.

In the ancient Tertiary strata the *Castanea atavia* has slightly toothed, or nearly toothless leaves, devoid of thorny points. From the primary vein spring, at a distance from one another, curved secondary veins.

In the Middle Tertiary strata are found leaves of the *Castanea atavia* closely approaching the *Castanea vesca* by approximate secondary veins, and by more numerous and protruding teeth, which, however, are still without thorny points.

In still more recent strata of the Tertiary formation there are found here and there thorny points on the teeth.

In the latest Tertiary strata the leaves of the fossil species are nearly identical with those of the *Castanea vesca.* The secondary veins are more approximate and almost rectilinear, while the teeth are set with thorns.

In all strata where leaves of the *Castanea atavia* have been found, the male catkins of that species have also been collected, which differ from those of the *Castanea vesca* by having somewhat smaller flowers. Examples of these are also added to the collection.

3356. Eocene Fossils. Typical collection, comprising 100 species. *R. Damon.*

3357. Rocks, sedimentary, volcanic, and plutonic. Typical collection, comprising 100 specimens. *R. Damon.*

3357a. Table of British Strata, showing the order of their superposition, and the relative thickness of the Formations.

Henry William Bristow, F.R.S., Director of the Geological Survey of England and Wales.

In the construction of this table, the object has been to produce a cheap diagram for educational purposes, and for illustrating lectures on geology.

When thus used, the four columns into which the table is divided may be printed in separate slips, and then coloured and mounted side by side. Each slip being complete in itself, any one, two, or more may be employed to suit the special purposes for which they are required. Thus, for elementary classes the first three columns may be all that are needed, while for more advanced classes, and in systematic lectures on geology, all may be made use of.

The mode here adopted of showing the grouping and order of succession of the various geological formations in parallel columns in juxtaposition with each other, places the facts before the eye in the most striking and comprehensive way. It has also the recommendation of cheapness, an important consideration in the case of schools.

For reference in the study as well as *on an enlarged scale* as a diagram, the table is susceptible of extension, as additional parallel columns may be filled up with (*a*), the names of the fossils most common in the several formations in different districts; (*b*), the lithological and local characters of the various strata; (*c*), the minerals usually found in or associated with them; (*d*), the useful purposes to which the strata and the mineral substances they contain are applied in the arts, manufactures, &c.; and (*e*), the prevailing agricultural characters and peculiarities of the different formations.

3358. British Rocks. A typical collection of aqueous, metamorphic, plutonic, and igneous rocks. *J. R. Gregory.*

3359. Collection of Fossils.

Dr. Acland, F.R.S., on behalf of the Radcliffe Trustees.

3360. British Typical Fossils. An elementary collection arranged stratigraphically. *J. R. Gregory.*

3361. Diagrams for Lecture Purposes, Two. The drawings enlarged from Davidson's Monograph of the British Fossil Brachiopoda.

George Sharman, Museum of Practical Geology.

Illustrations of characteristic British Carboniferous Brachiopoda.
Illustrations of characteristic British Brachiopoda, from various formations.

3361a. Collection of Fossils most characteristic of the different formations in Russia. 214 specimens.

Mining School, St. Petersburg.

1. Eurypterus Fischeri, Eichw. -	Upper Silurian.	Rotzeküll, Oesel.
2. Asaphus expansus, Lin. -	Lower Silurian.	Duboviki, St. Petersburg.
3. Illænus crassicauda, Schlth. -	„	Popovka, „
4. Amphion Fischeri, Eichw. -	„	Pulkova, „
5. Lituites convolvens, Schlth. -	„	Reval, Esthonia.
6. Orthoceras vaginatus, Schlth. -	„	„ „
7. „ duplex, Wahlb. -	„	Narva, „
8. Euomphalus qualteriatus, Schlth.	„	Reval, „
9. Spirifer superbus, Eichw. -	Upper Silurian.	Petropavlovsk, Ural.
10. Atrypa prunum, Dalm. -	„	Lode, Esthonia.
11. „ arimaspus, Eichw. -	„	Petropavlovsk, Ural.
12. Rhynchonella Wilsoni, Sow. -	„	Johannis, Esthonia.
13. „ nucella, Dalm. -	Lower Silurian.	Popovka, St. Petersburg.
14. Pentamerus esthonus, Eichw. -	Upper Silurian.	Kattentak, Esthonia.
15. „ borealis, Eichw. -	„	Hapsal, „
16. „ acutolobatus, Sandb.	„	Petropavlovsk, Ural.
17. „ Knightii, Vern. -	„	Petuhovsk, „
18. „ baschkiricus, Vern.	„	Satkinski Pristan, Ural.
19. „ vogulicus, Vern. -	„	Bogoslovsk, Ural.
20. „ „ Vern. -	„	„ „
21. Porambonites æquirostris, Schlth.	Lower Silurian.	Sommerhausen, Esthonia.
22. Porambonites Tscheffkini, Vern.	„	Pulkovo, St. Petersburg.
23. „ reticulatus, Pand.	„	Gostinopolskaia Pristan, Novgorod.
24. Platystrophia lynx, Eichw. -	„	Pulkova, St. Petersburg.
25. Orthis obtusa, Pand. - -	„	Popovka, „
26. „ extensa, Pand. - -	„	„ „
27. „ calligramma, Dalm. -	„	„ „
28. „ parva, Pand. - -	„	Pulkovo, „
29. Orthisina plana, Pand. -	Lower Silurian.	River Ishara, „
30. „ anomala, Schlth. -	„	Reval, Esthonia.
31. „ hemipromites, Buch.	„	Pulkovo, St. Petersburg.
32. „ adscendens, Pand. -	„	Popovka, „
33. „ Verneuilli, Eichw. -	„	Reval, Esthonia.
34. Leptæna Humboldtii, Vern. -	„	Erras, „
35. „ imbrex, Pand. -	„	Teve, „
36. „ transversa, Pand. -	„	Pulkovo, St. Petersburg.
37. „ oblonga, Pand. -	„	„ „
38. „ uralensis, Vern. -	Upper Silurian.	River Tsvestka, Ural.
39. Siphonotreta unguiculata, Eichw.	Lower Silurian.	Popovka, St. Petersburg.
40. Siphonotreta verrucosa, Eichw.	„	Pulkovo, „
41. Obolus Apollinis, Eichw. -	„	Narva, Esthonia.
42. Crania antiquissima, Eichw. -	„	Popovka, St. Petersburg.
43. Echino-encrinus angulosus, Pand.	„	„ „

44. Cryptocrinus lævis, Pand.	Lower Silurian.	Popovka, St. Petersburg.
45. Hemicosmites pyriformis, Buch.	"	Pulkovo, "
46. Heliocrinus balticus, Eichw.	"	Reval, Esthonia.
47. Glyptosphærites Leuchtenbergii, Volb.	"	Popovka, St. Petersburg.
48. Echinosphærites aurantium, Wahlb.	"	" "
49. Chætetes petropolitanus, Pand.	"	Pulkovo, "
50. Astylospongia globosa, Eichw.	"	Popovka, "
51. Pseudosiphonia cylindrica, Eichw.	"	" "
52. Pterichthys (Asterolepis) Milleri, Ow.	Devonian	River Aa, Livonia.
53. Holoptychius nobilissimus, Ag.	"	River Priksha, Novgorod.
54. Dendrodus biporcatus, Ow.	"	River Aa, Livonia.
55. Chelyophorus, sp.	"	Orel.
56. Gomphoceras rex, Pacht.	"	Zadonsk, Voroneje.
57. Gomphoceras sulcatulum, Vern.	"	River Siass, St. Petersburg.
58. Arca oreliana, Vern.	"	Orel.
59. Avicula Woerthii, Vern.	"	Gostinopolskaia Pristan, Novgorod.
60. Spirifer Archiacii, Sow.	"	Teletz, Orel.
61. " Anosofii, Vern.	"	Voroneje.
62. " curvatus, Schnur.	"	Lechki, Voroneje.
63. " aculeatus, Schnur.	"	Muraievna, Riazan.
64. Athyris concentrica, Buch.	"	Teletz, Orel.
65. " subpyriformis, Sem. Möll.	"	Muraievna, Riazan.
66. Athyris Puschiana, Sem. Möll.	"	" "
67. " pectinata, Sem. Möll.	"	Ulabie, Tula.
68. Retzia tulensis, Pand.	"	Malevka, Tula.
69. Atrypa reticularis, Lin.	"	Gostinopolskaia Pristan, Novgorod.
70. Atrypa reticularis, Lin.	"	Kadinskaia Pristan, Ural.
71. " Duboisii, Vern.	"	" "
72. " latilinguis, Schnur.	"	" "
73. Rhynchonella Panderi, Sem. Möll.	"	Malevka, Tula.
74. Rhynchonella livonica, Buch.	"	Zadonsk, Voroneje.
75. " Meyendorfii, Vern.	"	Pskof.
76. Rhynchonella cuboides, Sow.	"	Sulem, Ural.
77. Orthis striatula, Schlth.	"	Gostinopolskaia Pristan, Novgorod.
78. Leptæna, Asella.	"	Voroneje.
79. Chonetes nana, Vern.	"	Malevka, Tula.
80. Stropholosia subaculeata, Murch.	"	Zadonsk, Voroneje.
81. Productus Panderi Sem., Möll.	"	Malevka, Tula.
82. " fallax, Sem., Möll.	"	"
83. Phillipsia mucronata, M'Coy.	Mountain Limestone.	Borovitshi, Novgorod.

84. Phillipsia pustulata, Schlth.	Mountain Limestone.	Tshernishino, Kaluga.
85. Allorisma regularis, King.	„	Borovitshi, Novgorod.
86. Spirifer mosquensis, Fisch.	„	Verei, Moscow.
87. „ „ „	„	Deviatino, Olonetz.
88. „ striatus, Mart.	„	River Indiga, Timan.
89. „ trigonalis, Mart.	„	Steshovo, Tver.
90. Spiriferina Saranæ, Vern.	„	River Indiga, Timan.
91. Athyris ambigua, Sow.	„	Steshovo, Tver.
92. Camarophoria plicata, Kut.	„	Taroslavka, Ural.
93. Streptorhynchus crenistria, Phill.	„	Staritza, Tver.
94. Productus scabriculus, Mart.	„	River Nara, Kaluga.
95. „ costatus, Sow.	„	Sloboda, Tula.
96. „ tubarius, Keys.	„	Kremenskvie, Kaluga.
97. „ undatus, Vern.	„	Tarussa, Kaluga.
98. „ punctatus, Mart.	„	Sloboda, Tula.
99. „ Humboldtii, D'Orb.	„	River Indiga, Timan.
100. „ cora, D'Orb.	„	Kassimof, Riazan.
101. „ longispinus, Flem.	„	Steshovo, Tver.
102. „ semireticulatus, Mart.	„	Staritza, Tver.
103. „ striatus, Fisch.	„	Borovitshi, Novgorod.
104. „ giganteus, Mart.	„	Voronovo, Kaluga.
105. „ „	„	Borovitshi, Novgorod.
106. „ mammatus, Keys.	„	River Zilma, Timan.
107. „ semireticulatus var. Boliviensis, D'Orb.	„	Saraninsk, Ural.
108. Coscinium cyclops, Keys.	„	River Indiga, Timan.
109. Polypora orbicribrata, Keys.	„	„ „
110. Chaetetes radians, Fisch.	„	River Tagashma, Olonetz.
111. Syringopora conferta, Keys.	„	River Sopliussa, Timan.
112. Lonsdaleia floriformis, Flem.	„	Gurieva, Tula.
113. Amplexus arietinum, Fisch.	„	River Kumish, Ural.
114. Fusulina cylindrica, Fisch.	„	Zarel Kurgan, Samara.
115. Clydophorus Pallasi, Vern.	Permian	Kazan.
116. Pecten Kokscharofii, Vern.	„	Kirilof, Novgorod.
117. Avicula speluncaria, Schlth.	„	Kazan.
118. Terebratula elongata, Schlth.	„	River Dioma, Ural.
119. Spirifer Schrenkii, Keys.	„	Kirilof, Novgorod.
120. „ rugulatus, Kut.	„	River Termak, Samara.
121. Athyris pectinifer, Sow.	„	Kirilof, Novgorod.
122. „ Royssiana, Keys.	„	„ „
123. Camarophoria superstes, Vern.	„	„ „
124. Productus hemisphaerium, Kyt.	„	River Termak, Samara.
125. Productus tenuituberculatus, Barbt.	„	Kirilof, Novgorod.
126. Productus Cancrini, Vern.	„	Makarief, Kazan.
127. Stropholosia horrescens, Vern.	„	Kirilof, Novgorod.
128. Stropholosia Wangenheimii, Vern.	„	Grebeni, Orenburg.

129. Avicula Dalialama, Vern.	Trias	Bogdo, Steppe of Kirghises.
130. Ichthyosaurus sp.	Jura	River Volga, Simbirsk.
131. Ammonites Jason, Ziet.	„	Koroshovo, Moscow.
132. „ alternans, Buch.	„	River Petshora, Timan.
133. „ Brightii, D'Orb.	„	Skopin, Riazan.
134. „ sublaevis, Sow.	„	Telatma, Tambof.
135. „ Koenigii, Sow.	„	Koroshovo, Moscow.
136. „ virgatus, Fisch.	„	„ „
137. „ catenulatus, Fisch.	„	„ „
138. „ Kaschpuricus, Trautsch.	„	Syzran, Simbirsk.
139. „ Ischmae, Keys.	„	River Petshora, Timan.
140. „ uralensis, D'Orb.	„	„ Sosva, Ural.
141. „ Kirghisensis, D'Orb.	„	Saragul, Orenburg.
142. Belemnites absolutus, Fisch.	„	Koroshovo, Moscow.
143. „ curtus, Eichw.	„	River Petshora, Timan.
144. „ Panderianus, D'Orb.	„	Gorodishte, Simbirsk.
145. „ magnificus, D'Orb.	„	„ „
146. „ russiensis, D'Orb.	„	„ „
147. Pleurotomaria Bloedeana, D'Orb.	„	Koroshovo, Moscow.
148. „ Buchiana, D'Orb.	„	„ „
149. Astarte Duboisiana, D'Orb.	„	„ „
150. Lucina Phillipsii, D'Orb.	„	Gorodishte, Simbirsk.
151. Lyonsia Alduinii, D'Orb.	„	Koroshovo, Moscow.
152. Panopæa peregrina, D'Orb.	„	„ „
153. Pholadomya mediana, Eichw.	„	River Sosva, Ural.
154. Thracia Frearsiana, D'Orb.	„	„ „ „
155. Mytilus vicinalis, D'Orb.	„	„ „ „
156. „ Strajevskianus, D'Orb.	„	„ „ „
157. Lima consabrina, D'Orb.	„	Koroshovo, Moscow.
158. Pinna sublanceolata, Eichw.	„	River Sosva, Ural.
159. Avicula cuneiformis, D'Orb.	„	Koroshovo, Moscow.
160. Ancella mosquensis, Fisch.	„	„ „
161. Gryphaea dilatata, Sow.	„	Telatma, Tambof.
162. Terebratula Rogeriana, D'Orb.	„	Koroshovo, Moscow.
163. „ Fischeriana, D'Orb.	„	„ „
164. „ Strogonofii, D'Orb.	„	River Sosva, Ural.
165. Rhynchonella varians, Buch.	„	Telatma, Tambof.
166. „ loxiae, Fisch.	„	Koroshovo, Moscow.
167. „ oxyoptycha, Fisch.	„	„ „
168. „ grosse-sulcata, Eichw.	„	River Sosva, Ural.
169. Ammonites versicolor, Trautsch.	Neocomian	Simbirsk.
170. „ discofalcatus, Lahus.	„	„
171. „ fasciato-falcatus, Lahus.	„	„

172. Ammonites elatus, Trautsch.	Neocomian	Simbirsk.
173. Astarte porrecta, Buch.	"	"
174. Avicula Cornueiliana, D'Orb.	"	"
175. Pecten crassitesta, Roem	"	"
176. Inoceramus ancella, Trautsch.	"	"
177. Rhynchonella obliterata, Lahus.	"	"
178. Ancyloceras simbirskensis, Tazyk.	Gault	"
179. Ammonites Deshayesii, Leym	"	"
180. " bicurvatus, Mich.	"	"
181. Belemnitella mucronata, D'Orb.	Upper Chalk	Shilovka, Simbirsk.
182. Janira simbirskensis, D'Orb.	"	Tazykovo, "
183. Lima bistriata, Lahus.	"	" "
184. " semisulcata, Desh.	"	" "
185. Pecten undulatus, Nils.	"	" "
186. Avicula lineata, Roem	"	Simbirsk.
187. Inoceramus Cripsii, D'Orb.	"	"
188. Ostrea semiplana, Sow.	"	Maza, Simbirsk.
189. " vesicularis, Lamk.	"	" "
190. Terebratula obesa, Sow.	"	Tazykovo, Simbirsk.
191. " carnea, Sow.	"	" "
192. Magas pumilus, Sow.	"	" "
193. Rhynchonella octoplicata, Sow.	"	" "
194. Crania parisiensis, Defr.	"	" "
195. Ananchytes ovatus, Lamk.	"	" "
196. Nummulites distans, Desh.	Eocene	Simferopol, Crimea.
197. Buccinum baccatum, Bast.	Miocene	Stavrofka, Cherson.
198. Trochus podolicus, Dub.	"	Kamenka, Podolia.
199. " patulus, Brocc.	"	Vishnevetz, Volhynia.
200. Turbo chersonensis, Barbt.	"	Stavrofka, Cherson.
201. Cerithium disjunctum, Sow.	"	" "
202. " scabrum, Oliv.	"	Potshaievo, Volhynia.
203. Natica millepunctata, Lamk.	"	Vishnevetz, "
204. Mactra podolica, Eichw.	"	Stavrofka, Cherson.
205. Ervilia podolica, Eichw.	"	Kremenetz, Volhynia.
206. Tapes gregorea, Partsch.	"	" "
207. Lucina borealis, Lin.	"	Potshaievo, "
208. Pectunculus pilosus, Lin.	"	Vishnevetz, "
209. Cardium obsoletum, Eichw.	"	Stavrofka, Cherson.
210. " protractum, Eichw.	"	Kremenetz, Volhynia.
211. " Fittani, D'Orb.	"	Kalfa, Bessarabia.
212. " littorale, Eichw.	"	Vosnessensk, Cherson.
213. Congeria simplex, Barbt.	"	Gnilolofskaia, "
214. Ostrea digitalina, Eichw.	"	Vishnevetz, Volhynia.

3325. Series of Leaf Remains, from the Lower Bagshot beds (Middle Eocene), collected on the coast between Poole Harbour and Bournemouth. *J. Starkie Gardner.*

These leaves occur in isolated lenticular patches, usually of small extent, and were deposited in fresh water, which probably flowed from the north-west.

Their horizon is slightly higher than the well-known leaf beds of Alum Bay, the flora of which presents considerable differences in character. Collections from Alum Bay are in the British and Jermyn Street Museums.

3362. Collection of Fossils from the Gault, &c. at Folkestone. *J. Starkie Gardner.*

Crustacea, including about 115 specimens of brachyura, 10 anomura, 115 macrura, mostly with limbs perfect. Several of the species are still undescribed.

Gault coniferæ. Original specimens described by W. Carruthers, F.R.S.

Gault corals.

Grey chalk and gault echinoderms of the genera Cidaris, Pseudodiadema, Salenia, and allied genera.

Gasteropoda of the gault, illustrating the families aporrhaïdæ, scalidæ, and rissoidæ, described in the Geological Magazine for 1875–76.

3363. Collection of Typical Trachytes, consisting of some fifty specimens, arranged according to the system of the contributor. *Dr. J. Szabo, Buda-Pesth.*

3364. Thin polished plates of Trachytes, prepared at the University Institute for microscopic observation.
Dr. J. Szabo, Buda-Pesth.

3365. Illustrations of a New Method of determining Felspar by the character of the blow-pipe flame, exhibited in diagrams according to the system of the exhibitor.
Dr. J. Szabo, Buda-Pesth.

3366. Collection of Nummulites, systematically arranged with specimens prepared by Hantke and Madarász.
Maximilian Hantken, Buda-Pesth.

3367. General Collection of Foraminifera.
Maximilian Hantken, Buda-Pesth.

3368. Collection of Bryozoa, consisting of finished specimens. *Maximilian Hantken, Buda-Pesth.*

3369. Hammer Holder and Waist-strap; one with hammer in the position when worn. Specially adapted for geologists in the field. *Thomas J. Downing.*

3370. Card-board Trays, showing various sizes suitable for holding and arranging specimens in the cabinet.
Thomas J. Downing.

3371. Tablet-wood, covered with coloured papers, for mounting geological specimens. *Thomas J. Downing.*

3372. Improved Cement for mending and mounting fossils.
Thomas J. Downing.

3373. Collection of Volcanic Rocks of the Prussian provinces of Nassau and the Rhine, and especially from the district round the Laacher See and the Sieben Gebirge, River Nahe, and Nassau. *B. Stürtz, Bonn.*

3374. Local collection of Trachytes from the neighbourhood of Kremnitz in Hungary. *B. Stürtz, Bonn.*

3375. Collection of Rock Specimens from the Island of Elba. *B. Stürtz, Bonn.*

3376. Collection of Volcanic Rocks from the neighbourhood of Naples. *B. Stürtz, Bonn.*

3377. Collection, for illustrating geological lectures, of 150 **Fossils**, in good condition, arranged according to the age of the formations in which they occur, and containing in systematic order the characteristic fossils of all the formations and most of their subdivisions. *B. Stürtz, Bonn.*

3379. Impressions on large plates of **Extinct Species** of **Animals** (saurians and fish), suitable for illustrating the study of palæontology. *B. Stürtz, Bonn.*

3379a. Collection of Minerals.
Royal School of Mines, Madrid.

3379. Collection of various kinds of Rocks, from different parts of Russia. 95 specimens. Value, 4*l*.
Mining School, St. Petersburg.

1. Granite. Serdobol, Finland.
2. „ (Rappa-Kivi). Wyborg, Finland.
3. Granite. Katharinenburg, Ural.
4. Green granite. Ilmen mountains, Ural.
5. Granite. Ilmen mountains, Ural.
6. Corundum-granite. Kyshtyn, Ural.
7. Gneiss. Katharinenburg, Ural.
8. „ Zlatoust, Ural.
9. „ River Wytim, Siberia.
10. Syenite. Bogoslovsk, Ural.
11. Uralite syenite. Turgoyak, Ural.
12, 13. Miascite. Ilmen mountains, Ural.
14. Diorite. Goroblagodatsk, Ural.
15. „ Miask, Ural.
16. Epidote-diorite. Olonetz.
17. Porphyrytic-uralite-diabasite. Katharinenburg, Ural.
18. Aphanitic-diabasite. Katharinenburg, Ural.
19. Green slate. Katharinenburg, Ural.
20. Oligoclase-hypersthenite. Valamo, Lake Ladoga.
21. Hornblendite. Goroblagodatsk, Ural.
22. Hornblendite, with zirkon. Miask, Ural.
23. Actinolite. Ufaleisk, Ural.
24, 25. Labradorite. Kamennoi Brod, Kiev.
26. Epidosite. Goroblagodatsk, Ural.
27. Garnet-rock. Turinsk, Ural.
28. Serpentine. Miask, Ural.
29. „ with diallage. Katharinenburg, Ural.
30. Schistose-serpentine. Katharinenburg, Ural.
31, 32. Beresite. Beresovsk, Ural.
33. Borsowite-rock. Kyshtym, Ural.
34. Mica-schist, with staurolite. Taganai, Ural.

35. Mica-schist, with garnet and staurolite. Taganai, Ural.
36. Mica-schist, with garnet and staurolite. Zlatoust, Ural.
37. Chlorite-slate. Werchneivinsk, Ural.
38. Chlorite slate, with tourmaline. Roshkino, Ural.
39. Talcoze-slate. Regewsk, Ural.
40. Listwenite. Ufoleisk, Ural.
41. Stacolumite. Voitzk, Archangel.
42. Quartz-porphyry. Isle Hoghland.
43. Felsite. Lake Aouschkul, Ural.
44. Variolitic-felsite. Altai, Siberia.
45. Orthoclase-labradorite porphyry. Isle Hoghland.
46. Hornblendic porphyry. Bogoslovsk, Ural.
47. Porphyrite. Goroblagodatsk, Ural.
48. Plagioclase-porphyry. Altai, Siberia.
49. Augite-porphyry. Blagodat, Ural.
50. Uralite-porphyry. Katharinenburg, Ural.
51. Oligoclase-diabasite porphyry. Aiatsk, Ural.
52. Felsitic-retinite (Kulibinite). Nertchinsk, Siberia.
53. Amorphic-trapp (Sordowalite). Serdobol, Finland.
54. Trachyte. Kasbek, Caucasus.
55. Hornblendic-andesite. Koktebel, Crimea.
56. Augite-andesite. Kasbek, Caucasus.
57. Andesitic-lava. Kasbek, Caucasus.
58. Obsidian. Goktcha, Caucasus.
59. Anamesite. Rowno, Volhynia.
60. Basalt. Goktcha, Caucasus.
61. Rock salt. Iletzk, Orenburg.
62. Marble. Gornoshitsk, Ural.
63. Limestone. Sanarka, Ural.
64. Oolite. Kamenka, Podolia.
65. Ophiocalcite. Kussinsk, Ural.
66, 67, 68. Dolomitic-marble. Tivdia, Olonetz.
69. Dolomitic-marble. Kapselga, Olonetz.
70. Magnesite. Poliakovsk, Ural.
71. Porous quartz. Beresovsk, Ural.
72. Lydite with anthracite. Isle Volk, Lake Onega.
73. Hornstone with silver. Altai, Siberia.
74. Jasper. Lake Kalgan, Ural.
75. Jasper. Poliakovsk, Ural.
76. Magnetite. Blagodatsk, Ural.
77. Specular-iron-schist. Krivoi-Rog, Cherson.
78. Spathose-iron. Satkinsk, Ural.
79. Sphaerosiderite. Kromy, Orel.
80. Chromite. Ural.
81. Graphite. Tunkinsk, Siberia.
82. Graphite. Tunguska, Siberia.
83. Anthracite. Grushevka, Chain of the Donetz.
84. Coal. Chain of the Donetz.
85. Coal. Regewsk, Ural.
86. Coal. Tovarkova, Tula.
87. Boghead-coal. Muraievna, Riazan.
88. Iet. Tkvibul, Caucasus.
89, 90, 91. Sandstone. Shoksha, Olonetz.
92. Sandstone. Vytegra, Olonetz.
93. Apatite-sandstone. Kursk.
94. Apatite-sandstone. Tambof.
95. Alumstone. Zaglic, Caucasus.

3379b. Specimens of Minerals of the **Porphyry** Class (23). *Prof. von Lasaulx, Breslau University.*

3379c. Microscopic Slides (33). *Prof. von Lasaulx, Breslau University.*

II.—MINING.

3383. Ramsay's Water Gauge, for measuring the friction of ventilating currents in mines or other places. *D. P. Morison.*

The india-rubber tube is connected with the return airway of the mine, the other compartment of the apparatus being in communication with the external atmosphere; the friction, or difference of density of the two atmospheres, is indicated by the difference of level of the two columns of water. Advantages claimed are especially the facility of observation and the steadiness of the columns.

3384. Model of a Ventilator (Guibal).
Royal Saxon Mining Academy, Freiberg.

3384a. Indicator for **Mining Purposes** for the **prevention** of **Explosions,** and for demonstrating the presence of choke-damp in disused pits or old shafts.
Dr. F. Schöpfleuthner, Vienna.

This is a kind of balance to be set up in coal mines. It announces immediately any evolution of gas, enabling the miners to protect themselves at once against this dangerous substance. The existence of the gas is signalled by an electric telegraph. A very light sphere of glass hangs from the one end of the beam of a balance, and is supplied with pure air from the downcast shaft in such a way that between the admission tube and the sphere some air always escapes to prevent the gas from penetrating the sphere. When, however, by the presence of fire-damp the atmosphere surrounding the apparatus is specifically lighter than pure air, the sphere, in consequence of its weight, will sink and make contact with the electrical conductor of the signalling apparatus. By this means both the miners and the men at the head of the mine receive early notice of the presence of gas in the mine. When several instruments are employed an ordinary numbered table is necessary.

3384a. Drawing of Guibal Ventilator for Mines.
David Pemberton Morison.

Drawing of Patent self-contained Guibal Ventilator for Mines, Ships, &c. *David Pemberton Morison.*

3384b. Model of Cooke's Displacement Ventilator.
John Cooke.

This is a rotary engine, as distinguished from centrifugal exhausters or blowers, and is particularly applicable to the ventilation of mines.

The model exhibits how in place of having the drum cranks, levers, and connecting rods the full length joining the centres of the arcs and drums to their working axes respectively, their dimensions, weights, and speed of reciprocation are reduced to a minimum, while at the same time the deflection of the shutter is almost eliminated, by getting firm hold of it at each end, as far down as is desirable.

The principles involved are two:—

1. Maintaining the same relative proportions of the crank, lever, and connecting rod; and
2. Adjusting the angle of the cranks and of the radius rods or intermediate shafts to harmonise with the oscillation of the shutter.

3385. Mining Barometer. *Elliott Brothers.*

3386. Mining Thermometer. *Elliott Brothers.*

3386a. Davis's Mining and Surveying Aneroid Barometer, reading altitudes to 1 foot. *John Davis and Son.*

This instrument is specially for the use of mining engineers and surveyors, for the purpose of readily ascertaining slight variations in gradients, levels, &c.; and, from its extreme sensitiveness, will be found of considerable utility in mining and surveying work generally. Besides its extreme sensitiveness, the speciality claimed for the instrument is an arrangement of the scale of altitudes which admits of subdivision by a vernier, hitherto impracticable, owing to the altitude scale in ordinary use being a gradually diminishing one, to which a vernier cannot be applied. In the present instrument the action has been so adjusted as to give accurate readings upon a regular scale of altitudes, the barometrical scale of inches being made progressive in length, so as to afford the correct relative readings with the scale of altitudes. For mining operations the entire circle of the dial is graduated to represent 6 in. of the mercurial column—that is, from 27″ to 33″. This scale affords observations from about 2,000 ft. below sea level to 4,000 ft. above. The finest division of the altitude scale (1-100th) represents 10 feet measurement, which can be again divided by the vernier scale to single feet. The vernier scale is moved by rack-work adjustment, and a lens, which rotates on the outer circumference of the instrument, facilitates the reading of minute quantities. For surface surveying purposes, where it is not required to be used below sea level, the instrument is made with the scale divided from 25 to 31 in., thus giving an altitude scale of 6,000 ft. above the sea level only; and with this open scale, and the assistance of the vernier, the same minute readings to single feet may easily be taken. The instruments are also constructed for measuring much greater altitudes, that is 10,000, 15,000, or 20,000 ft., but with these scales the measurement cannot be made quite so minute as in the more open scales. The instrument is 4½ inches in diameter, and is provided with a leather sling case, thus making it sufficiently portable for all practicable purposes.

3386b. Davis's Improved Colliery Barometer, specially adapted for moist climates. *John Davis and Son.*

The necessity of a travelling screw is dispensed with by choking partially the neck of the tube, thus preventing the possibility of the mercury breaking the end of the tube by violent concussion in transit. The travelling screw (or the screw at bottom for driving the mercury to the top of the tube) being dispensed with, the cistern can be made entirely of boxwood. All the parts of the case are well screwed together, thus making the instrument suitable for moist atmospheres, such as pit banks.

3387. Air Meter, used for the ventilation of mines and other large buildings. *Francis Pastorelli.*

This consists of a horizontal box, with a dial, upon which are divided circles and indexes; this is mounted upon three vertical pillars, fixed into a brass base; solidly attached is a vertical ring; within this are eight vanes fixed to one end of a horizontal axis, the other terminating with an endless screw, which works a series of wheels in the box, and their revolutions are recorded by indexes on the dial; some of the working parts are jewelled to obtain the minimum amount of friction.

The large circle is divided into 100 parts which represent feet; one revolution of its hand is equal to 100 feet; now as the hand of the small circle goes 10 times as slow, it is evident, that, while the former makes one complete revolution, the latter will only have made one-tenth of a revolution; therefore, when it has made one complete revolution, it will indicate 1,000 feet. The small circles are lettered hundreds, thousands, &c., up to 10 millions, and numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 0.

For measuring an air current of a low velocity the readings on the large circle are taken, for a high velocity on both.

3387a. Improved form of **Air-meter** for use in coal mines, hospitals, &c. *E. Cetti & Co.*

3388. Patent Electric Velocimeter, for ascertaining the velocity of air currents in any part of the workings of a coal mine at a distance of two or more miles from it, in a chosen station above ground. *Francis Pastorelli.*

This consists of three parts:—

1. Four hollow hemispherical cups are fixed to the ends of four strong metal arms (at right angles) radiating from a central boss. At right angles to it is attached the horizontal axis, which is mounted in a rectangular metal box; each revolution of the cups causes a contact to be made.

2. The receiving instrument has a circular box with a dial mounted upon a metal base; it is worked by an electro-magnet; by its means each revolution of the cups is indicated, and motion given to a series of wheels. On the face of the instrument are divided circles and indexes, which register from 10, 100, 1,000 and so on up to 10,000,000 feet.

3. Attached to its side is a commutator, so that the current can be opened or closed for timing or other purposes; it is an ivory handle carrying an index, which can be moved to point to off or on at pleasure; it will also serve as a means to prevent unnecessary exhaustion of the battery.

4. A Leclanché battery of six No. 2 cells is connected with the above, so that each revolution of the cups may be electrically transmitted and indicated on the large circle of the receiving instrument which represents 10 feet of velocity. The receiving instrument can be placed in any convenient position above ground. The cup arrangement (Dr. Robinson's with mechanical modifications) is intended to be used in the mine; in the air-ways or workings where the velocity of the air current is to be ascertained, its velocity is registered on the dials of the receiving instrument.

The inventor does not introduce this instrument with the idea that explosions will be prevented if it were generally adopted, but he has a strong impression that, by its use under proper regulations, it will be the means of diminishing them.

3388b. Air Meter for testing ventilation in mines, hospitals, and public buildings. *L. Casella.*

THEODOLITES, COMPASSES, &c.

3390. Mining Compass, with independent vernier readings. *Patrick Adie.*

3390a. Casartelli's Improved Miners' Dial. *Joseph Casartelli.*

The first improvement (1861) consisted in mounting the sight-plate on axes cast on the compass-box, and attaching the arc for giving the angles of inclination to one of the axes, with the index so fixed as to be moved by the sight-plate when inclined to sight up or down the roads, and so give the angle of inclination. The second improvement (1874) consists in substituting for the arc a semi-circular limb fixed to the compass-box by pivots in the line N and S in such manner as not to obstruct the view through the sights. The degrees of angle are graduated on the face, and read off by indexes attached to the sight-plate, which ride over the face of the semi-circle when the plate is inclined for the purpose of taking a sight in steep mines. When the semi-circle is not required, it is simply folded down on the outside of the compass-box. In practice this is found to be an exceedingly convenient arrangement.

3390b. 12-inch Circular Protractor, divided to 15 minutes for plotting in connexion with the dial. *Joseph Casartelli.*

3390c. German Compass, which has been used for a great number of years in the different operations, made at the mines of Almaden. *Royal School of Mines, Madrid.*

3390d. 5-inch Miners' Compass. *G. W. Strawson.*

3390e. 2¼-inch Miners' Compass with folding sights. *G. W. Strawson.*

3391. Mining Compass, with arrangement for suspending needle 7 cm. long, circle graduated in degrees. *A. and R. Hahn, Cassel.*

3392. W. König's Telescope Mining Compass, with level and graduated arc, together with Hörold's centre foot-plate in box with lock.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

This instrument is used by mine surveyors, and at official revisions of mine surveys.

3394. Steel Measuring Tape for mining surveyors, in case. *C. Osterland, Freiberg.*

To be used principally in conjunction with a mine theodolite constructed by the exhibitor.

3395. Head with screw for the steel tape. *C. Osterland, Freiberg.*

3396. Travelling Box Compass, with brass support adapted for levelling with a small suspending apparatus, graduated arc, and appurtenances. *C. Osterland, Freiberg.*

Constructed for travellers in thinly populated countries, and is adapted for attaching to the saddle.

3397. Mine Surveying Instrument, consisting of compass, suspending apparatus, and protracting plate clinometer, and two cases. *A. Lingke and Co., Freiberg, Saxony.*

3397a. Henderson's Hypo-thonite, with stand, is an improved form of the same kind of instrument generally in use for rough surveying, especially in underground workings of collieries and other mines. *Ridley Henderson.*

The improvements are additions to the ordinary Miner's Dial or Circumferentor, viz. :—1st, a radiating limb and sights worked by rack and pinion attached to a quadrant, for taking vertical angles. 2nd, a similar arrangement, working a circular plate with sights and vernier, for taking horizontal angles. 3rd, a circular level, ground to a radius of about 15 feet, fitted *inside* the dial on the base plate, in lieu of the usual cross levels *outside*. 4th, fitted into the same case, with sockets screwed to receive three legs either permanent or temporary, is a ball and socket stand, with adjusting rod which enables the instrument to be correctly adjusted almost instantaneously, while the parallel plates are in any position within 25 degrees of the perpendicular. Where the ground to be surveyed is slippery, or the vein thin, with a low roof, and its inclination steep, this arrangement of stand is of great advantage to correct and rapid surveying.

3397b. Davis's Improved Clinometer with tripod, which folds up and forms a walking-stick. *John Davis and Son.*

This clinometer is much used in geological surveys; the arc being of a large size, gives by aid of the levels the gradient of stratum very accurately.

The special arrangement in this instrument is in the stand, also in the large size of the compass, which turns over, rendering the clinometer capable of doing the work of a level and dial approximately. Where great accuracy is not required, it will save time and a more expensive instrument, and on account of its extreme portability may be used when a level or dial could not. Its outside dimensions are, when folded up, 6½″ by ½ ″ by 3″.

3397c. Davis's Improved Hedley, Dial, or Circumferentor, for mine surveying. *John Davis and Son.*

This dial combines all the latest improvements of the best Hedley, with the outside vernier of the theodolite.

The figuring is so arranged that the readings of the needle and the vernier tally, thus keeping one another in check. If the needle be used, the vernier will detect the slightest local attraction.

The Hedley sights and the vernier plate may be clamped, and the instrument can then be used as an ordinary rigid dial. One great advantage of this construction is that if the dial be out of adjustment, it is at once detected by comparing the vernier and needle readings.

The weight is not more than that of the ordinary Hedley, and it is equally compact.

3398. Prof. Junge's Levelling Staff for underground use. The divisions are cut out of a brass plate and illuminated by a sliding transparent glass screen placed in front of a candle, so that the divisions appear as alternate light and dark bands of about an inch in breadth.

Royal Saxon Mining Academy, Freiberg.

3399. Collection of various Mine Signals for subterranean measurement of angles with the theodolite.

Royal Saxon Mining Academy, Freiberg.

3400. Pocket Compass apparatus with stand.

F. W. Breithaupt and Son, Cassel (G. Breithaupt).

3418. Photograph of a small **Box Compass Apparatus.**

F. W. Breithaupt and Son, Cassel (G. Breithaupt).

3401. Six-inch **Theodolite,** with two **Telescopes,** by Messrs. Troughton & Simms, with adaptations for underground surveying, suggested by the contributor. *Walter Rowley, C.E.*

3393. Complete Mine Surveying Instruments, consisting of compass, suspender, protracting clinometer plate, pocket and case for the additional plate. *Otto Fennel, Cassel.*

3402. Mine Theodolite (No. 159), with stand and leather case. *Otto Fennel, Cassel.*

Differs from the preceding principally in the apparatus for adjusting the telescope.

3403. Photographs of mine-surveying instruments.
C. Osterland, Freiberg, Saxony.

3404. Small Repeating Theodolite for mine surveyors.
A. Lingke and Co., Freiberg, Saxony (M. Hildebrand and E. Schramm).

3405. Compass Attachment for the Theodolite.
A. Lingke and Co., Freiberg, Saxony (M. Hildebrand and E. Schramm).

3406. Mining Repeating Theodolite, with—

a. Box compass.
b. Two separate tripods.
c. Two signals,
d. Two signal lamps.
e. Suspender and appurtenances to the compass.

F. W. Breithaupt and Son, Cassel (G. Breithaupt).

With horizontal circle 12 cm. in diameter, and silver limb graduated into half degrees, the vernier indicating minutes and is covered with glass; the vertical circle and vernier are similarly divided, provided with transparent signals for use either below or above ground. The suspensory apparatus attached to the setting up compass was constructed by F. W. Breithaupt for the survey of the Hartz.

3407. Mining Theodolite, by Breithaupt and Son.
Royal High School of Industry, Cassel (W. Narten).

Mining Theodolite, with lateral telescope, constructed by F. W. Breithaupt and Son in 1864.—The two circles are divided upon silver and are protected by the covering invented by Breithaupt, the verniers also are enclosed in glass. The vertical circle is placed opposite to the telescope as a counterpoise. On the cylinder of the telescope axis a compass and a spirit-level can be placed. The spirit-level of the telescope for levelling lies with cylindrical pivots in bearers in front of the latter, and when the telescope is turned over it may be again turned upwards and observed. This theodolite also forms a convenient small universal instrument for astronomical observations. It has already been described in the fourth part of the "Magazin Mathematischer Instrumente," published by Breithaupt's establishment in the year 1860. A similarly constructed eccentric mining theodolite, referred to in 1876 by Prof. Bauernfeind, in his "Vermessungskunde," has been made by Ertel, of Munich.

SAFETY LAMPS.

3407a. Davy's Original Safety Lamp. *Royal Society.*

3408. Collection of Miners' Lamps of various designs.

Catalogue No.	Name of Lamp.	Description of Lamp.	Mainly used.	Approximate Date of Manufacture.	Velocity of Explosive Current requisite to render Lamp unsafe in Feet per Second (per Experiments of Lamp Committee of Mining Institute).
1	Common Davy -	Single gauze, without shield.	By Hewers and all classes of underground men in Northumberland, land, and generally used by Putters and Drivers.	Recent (Mills and Son).	8 feet.
2	Do. - -	Do. - - -	Do. - -	Recent (H. Watson).	„
3	Do. - -	Single gauze, with shield.	Do. - -	Do. - -	8·3 feet.
4	Modified type of Common Davy.	Single gauze, with shield and glass.	- - - -	About 1850 (Abbot).	—
5	Do. - -	Single gauze, with internal tube.	- - - -	No date (Errington).	—
6	Do. - -	Single gauze, self-extinguishing.	- - - -	Recent (Waring)	—
7	Do. - -	Do. - - -	- - - -	No date.	—
8	Do. - -	Do. - - -	- - - -	„ (Jones)	—
9	Common Davy -	Single gauze, ordinary type.	Generally - -	About 1840 - -	8 feet.
10	Do. - -	Single gauze, original type.	- - - -	„ 1820 - -	„
11	Modified Davy -	Single gauze, with modified lock.	- - - -	„ 1852 (Watson).	„
12	Ordinary Davy -	Exposed to fire for two days.	- - - -	About 1860 - -	„
13	Copper Davy -	Surveying lamp with shield and bull's-eye.	Mining Surveyors.	Recent (Watson)	9 feet.
14	Clanny - -	Glass round the flame and gauze above.	Stonemen, Waggonway-men, &c., in Northumberland and Durham, and generally.	„ (Mills) -	„
15	Do. - -	Do. - - -	Do. - -	„ (Watson)	„
16	Do. - -	Glass round, with patent lock.	- - - -	„ (Hall).	—
17	Do. - -	Glass round, with double glass.	- - - -	„ (Henderson).	—
18	Stephenson (Geordie).	Glass surrounded by gauze.	Yorkshire and generally.	„ (Mills) -	9 feet.
19	Do. - -	Do. - - -	Do. - -	„ (Unknown)	—
20	Do. - -	Do. - - -	Do. - -	„ (Watson)	9 feet.
21	Do. - -	Glass, with close top over glass.	- - - -	About 1865 (Hann).	Safe.
22	Do. - -	Glass, ordinary -	Generally - -	1816 (original type).	—
22a	Do. - -	Glass, with perforated shield.	- - - -	First experimental.	—

Catalogue No.	Name of Lamp.	Description of Lamp.	Mainly used.	Approximate Date of Manufacture.	Velocity of Explosive Current requisite to render Lamp unsafe in Feet per Second (per Experiments of Lamp Committee of Mining Institute).
23	Mueseler	Glass, with internal cone and gauze over top of glass.	Generally in France and Belgium.	Recent type, authorised by Belgian Government.	25 feet.
24	Do.	Do.	Do.	Ordinary type	11 feet.
25	Do.	Do.	- - - -	Modified (Abbot)	„
26	Wood's	Gauze cylinder surrounding flame inside chimney.	- - - -	1865 (experimental).	Safe.
27	Cail and Glover's	Double glass and gauze above.	- - - -	About 1850	9 feet.
28	Morrison's, No. 2	Double glass, with internal chimney.	- - - -	„ 1866	Safe.
29	Do.	Do.	- - - -	„ „ (common type).	„
30	Do.	Double glass, with J. A. R. Morison's lock.	- - - -	1868	„
31	Upton and Roberts.	Glass and close brass funnel.	- - - -	About 1840	11 feet.
32	Morrison's, No. 1.	Glass with internal gauze.	- - - -	„ 1866	Safe.
33	Watkin and Evans.	Double glass	- - - -	„ 1867	Unsafe.
34	Watson and Lambert.	Mica plates, gauze, and cone.	- - - -	„ 1850	„
35	Bainbridge	Glass and brass funnel.	- - - -	„ 1867	Safe.
36	Unknown	Do.	- - - -	Antique	Unsafe.
37	Hall's	Double glass and Geordie top.	- - - -	Recent.	—
38	Eloin	Brass with gauze and mica front.	- - - -	About 1850	Unsafe.
39	Dubrule's	Glass and gauze top.	- - - -	Antique	„
40	Stable Lamp	Davy with paraffin chimney and reflectors.	- - - -	Do.	„
41	Steel mill	Flint and steel striker.	- - - -	Antique	„
—	Owen's improved Davy.	Single gauze, improved body, and patent levered lock.	By Hewers and general use.	Owen's, 1875.	—
—	Owen's improved glass Davy.	Strong glass tube, with perforated copper air caps, top and bottom, with patent levered locks.	By Officials and Waggonway-men, Hookers-on, and in places where a good light is required.	„ 1876.	—
—	Owen's improved Clanny.	Glass round flame, and gauze above and patent levered lock.	Stonemen, Waggon-way-men, and general use.	„ 1875.	—

Catalogue No.	Name of Lamp.	Description of Lamp.	Mainly used.	Approximate Date of Manufacture.	Velocity of Explosive Current required to render Lamp unsafe in Feet per Second (per Experiments of Lamp Committee of Mining Institute).
—	Owen's improved patent Stephenson's.	Body and gallery for glass combined, and improved shape, with patent levered lock.	Yorkshire and generally.	Owen's, 1876.	—

North of England Institute of Mining and Mechanical Engineers.

3409. Rudiments of Apparatus constructed by **Sir Humphry Davy** during his researches on the **Safety Lamp.**
The Royal Institution of Great Britain.

Phil. Trans. 1815 to 1817.

3409a. Mining Lamp. *M. Bréguet, Paris.*

3410. Specimen of the General Map of the Belgian Mines (a chromo-lithographic sheet, $0\cdot46^{m}$ by $0\cdot60^{m}$, with a MS. or printed note).

This map, to a scale of 1 : 5000, represents a section of the coal basin comprised between two horizontal planes at the levels of 140 and 190 below the sea. It was executed by order of the Public Works Department, and the General Map will be completed in six or seven years. *J. van Scherpenzeel Thini, Liége.*

3411. Bidder's Patent Magnetic Lock for Miners' Safety Lamps. *S. P. Bidder.*

All previous inventions have failed to prevent the men from opening their lamps with forged keys or other implements, and it is well known that a large proportion of explosions have occurred from this dangerous practice. It is evident that safety can only be secured by rendering the opening of the lamp impossible by any means, short of its destruction, which are available to the colliers.

This important desideratum is supplied by these lamps, which are secured by a self-locking catch, which comes into action when the bottom of the lamp is screwed home, and it can only be opened by means of a powerful magnet, which is kept in a strong box, under lock and key, in charge of the lamp cleaner.

Another magnet may be put under the care of a fireman in the pit, whose duty it will be to re-light lamps which have been put out by accident and thus the inconvenience and loss of time involved in conveying lamps to the lamp-room on bank will be entirely obviated.

The locking arrangement, as will be seen, is extremely simple, and completely enclosed within the lamp, and protected from injury.

A number of these lamps can be opened in the time required to open one of the common locks, and a consideration of the accompanying engraving will at once convince the mining engineer of their superiority over every other lamp in use.

Every further information, and list of collieries where the lamps may be seen in use, can be obtained from S. P. Bidder, 24, Great George Street, Westminster, London, S.W., or from the makers.

The unlocking of these lamps by the apparatus for the purpose is very simple, and much more easily performed than with the ordinary key. The lock consists only of a piece of flat iron 2¾ inches by ¾ inch wide and ⅛ inch thick, to the end of which is attached the pin; this is kept in position by a strong spring underneath it, and projects into the upper rim of the lamp. It is impossible to unscrew the top until this pin is drawn by a powerful eight-bar magnet, the magnetism passing through the brass bottom, and drawing the pin down on the inside. If a large number of these lamps are required to be opened in a short time for cleaning, a set of electro-magnets, worked by a galvanic battery, placed in the lamp cabin is the most convenient arrangement.

3412. Apparatus for showing externally the mixture of gases existing in underground explorings. *M. Lemaire Douchy, Paris.*

2. MINING MODELS AND PLANS.

3413. Working Model of a proposed new system of Hand Drill for mining purposes. *Jos. P. O'Reilly.*

The drill consists of the following parts:—

(1.) The bit, made in the model of those employed for artesian borings; it adapts itself by a screw to the

(2.) Barrel. This is of cast steel and tubular, thus allowing the passage of a stream of water through the bit into the hole. It is fitted with a bearing on its upper extremity on which plays the

(3.) Water box, the water passing through holes in the barrel from the box. The water box is kept from turning with the drill by means of

(4.) An armlet or ring passed on the arm, and connected with the box by a short connecting rod. The end of the barrel is terminated by

(5.) A solid head, changeable, when worn.

Each blow of the hammer drives the water into the hole with a pressure proportional to the force of the blow, thus clearing away the débris from the bottom of the hole, and keeping the cutting edge cool. The cutting edge, or bit, may be renewed frequently and easily without involving a change of drill, and the carriage of an equal number of drills, as at present.

3414. Two Plans, illustrating the principal modes of **working Coal** in the Yorkshire mining district. *Walter Rowley, C.E.*

Showing the advantages for economy of working and ventilation of the "Long Wall" system, and the disadvantages resulting from the "Pillar and Stall" mode of working.

3305. Glass Model of the **Anthracite Coal Beds** of the Wurm basin, near Aix-la-Chapelle.

United Coal Mining Co., Aix-la-Chapelle (Director Hilt).

In this model the excessive contortion of the coal measures is shown by 15 vertical sections, drawn upon glass plates, to a true scale of $\frac{1}{4000}$ of the natural size, horizontal and vertical.

These sections are taken at intervals of 100 lachteus, about 226 yards, except Nos. 10 and 11, which are at double that distance, as between them there is a great fault which cannot be shown on the scale of the model.

The 18 workable seams are represented by special colours. The principal seams and the position of the faults are also shown upon a horizontal plane about 230 yards below the surface, which represents the present main level of the deep workings. The depth to the bottom of the basin is about 3,900 feet, and the total amount of coal contained in it is estimated at about 114,000,000 tons, or about 285 years' consumption at the present rate of working.

3306. Transverse Section through the **Anthracite Coal Beds** of the Wurm basin. Scale, 1 : 1000, 5·28 inches to 1 mile, vertical and horizontal. This is an enlargement of one of the sections in the Model No. 3305.

United Coal Mining Co., Aix-la-Chapelle (Director Hilt).

3282. Model of the Altendorf Trough, a double synclinal in the "Sonnenschein" seam.

"Berggewerkschaftskasse," Bochum, Westphalia.

Shows the stratification of the Flötz, Sonnenschein, and of the Flötz of the fat coal below it in the Altendorf Trough, as well as the (*darauf getriebenen Strecken und Abbaue*). By means of Profils made of glass, the (*überlagernden*) parts of the mountains are indicated.

The ground is removed down to the surface of the seam, upon which are indicated contour lines of equal depths, and the area of the seam worked out. The transverse section of the measures is shown upon the glass plates at the ends of the models.

3283. Fourteen Models of Faults in the Carboniferous rocks. *"Berggewerkschaftskasse," Bochum, Westphalia.*

Typical models for teaching purposes. The blue stripes represent (*Strecken*) in the first (*Sohle*); the red ones those in the second; the green ones those in the third (*Sohle*).

These illustrate the effects produced by dislocations upon the highly inclined strata of the Westphalian coalfield in producing repetition, overlap of seams, &c.

3415. Typical Plans, for showing the works in coal mines; scale, one thousandth (three chromolithographic sheets, $0\cdot60^{\mathrm{m}}$ by 0·80, with a printed note).

These plans, which are intended as a model for surveyors, may be used for teaching subterranean topography in technical schools. *J. van Scherpenzeel Thini, Liége.*

3416. General Vertical Sections, showing the order of the various **Seams** of **Coal** in the Yorkshire coalfield.

Walter Rowley, C.E.

3416a. General Plan of the **Royal Mines of Almaden,** presented in 1796 by Dr. Diego de Larrañaga. Copied by Dr. Enrique Bermejo, at Almaden, in April 1827.
Royal School of Mines, Madrid.

3416b. Plan, Outline, and **Section** of two furnaces for melting quicksilver, copied from those used formerly at the mines of Almaden, by Alesandro Sierra.
Royal School of Mines, Madrid.

3416c. Photograph of the General Plan of the Quicksilver Mines of Almaden, Spain, made in 1796, by Dr. Diego Larrañaga. *Royal School of Mines, Madrid.*

3416d. Photograph of a Plan made in 1830, by Dr. V. Romero, of Watt's Steam Engine, which was used at the mines for extracting water. *Royal School of Mines, Madrid.*

3416e. Photograph of a Plan of Furnaces for melting Quicksilver. *Royal School of Mines, Madrid.*

3419. Collection of forty-three **Thin Sections** of **Hungarian Trachytes** from specimens of the Imp. geologische Reichsanstalt at Vienna. *Voigt and Hochgesang, Göttingen.*

3420. Collection of fourteen **Thin Sections** of **Rocks** of **Monzoni,** according to the researches of Prof. G. von Rath.
Voigt and Hochgesang, Göttingen.

3421. Three Thin Sections of fossil vertebræ of **Ichthyosaurus, Notosaurus,** and **Squalidarium,** according to the researches of Prof. C. Hasse, Breslau.
Voigt and Hochgesang, Göttingen.

3334. Plans of the Royal Heinitz-Dechen Coal Mine, consisting of—
- *a.* General plan showing position of mine (6 sheets).
- *b.* Ground plan of the whole mine (6 sheets).
- *c.* 25 special ground plans (25 sheets).
- *d.* Profile plan (10 sheets).

Royal Mining Directory, Saarbrück.

3335. Transverse Section through the **Heinitz** and **Reden** mines, respectively through the "Fat Coal" and the "Flame Coal" part of the Saarbrück Coal Basin (7 sheets).
Royal Mining Directory, Saarbrück.

3336. Special Geological Maps (2 sheets), section Reden and section Dudweiler. *Royal Mining Directory, Saarbrück.*

3337. Sheets to illustrate **Position and Mining Drawing** in the Saarbrück district (3 sheets with cover).

Royal Mining Directory, Saarbrück.

3338. Explanation of the Exhibited Objects.

Royal Mining Directory, Saarbrück.

3345. Muthung's Survey Map of the mountain district of Upper Silesia, original drawing, scale $\frac{1}{8000}$ in nine special sections, from *a* to *i* of the chief section, No. 6, together with two network maps for the north-eastern and south-western part of the drawing lithographed on scale of $\frac{1}{100000}$.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

This map, executed to the scale of 1:8000, is based upon a special triangulation by Prof. Sadebeck, and Messrs. Sartor and Hörold, in which are inserted reduced copies of the official survey maps and other special plans of mines, railways, towns, &c. The rectangular network of the map is determined by parallels to the meridian of the chief trigonometrical point of the Trockenberg near Tarnowitz.

3346. Photographic reduction of the nine sections on a scale of $\frac{1}{25000}$, not retouched; carried out by Ed. v. Delden, Breslau, viz.,

a. Nine unmounted small sheets bound in card.

b. Nine small sheets mounted, like chief section No. 6 (3347) of the map drawing.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

a. shows the photographic reduction of the nine original sections above mentioned, as prepared by Ed. v. Delden of Breslau. On plate *b.* these nine small sheets appear mounted and united to a chief section of the network of the survey map. The maps 4–6 show the use of the photographic map on the scale of 1:25,000 as a topographical basis for various mining and other industrial purposes. The map shows the important mining districts of the towns Beuthen, Königshütte, and Kattowitz, being the first sheet of a new map of Upper Silesia, which was not only destined to exhibit the coal beds, but also the important deposits of zinc and lead ores of the Muschelkalk basin.

A special wall map is exhibited in which the mineral boundaries are shown in different colours, but, as in those before mentioned, faint black lines are used to show positions of places and boundaries of districts and mining rights. The map illustrating the projected water-supply represents a larger district on the same topographical basis, and shows the relation intended to be observed between the supply and the consumption.

3347. Principal Section, No. 6, of a map of a coal deposit and ore deposit in Upper Silesia, scale $\frac{1}{25000}$. To complete and elucidate this, Hörold's map of the ore deposits of the Polish Upper Silesian Muschelkalk is added, scale $\frac{1}{50000}$, together with a number of mountain profiles from Dr. Ferd. Römer's Geology of Upper Silesia.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

3348. Muthung's Survey Map of the mountain district of Beuthen, with coloured boundaries of the mining fields and districts, scale $\frac{1}{25000}$.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

3349. Survey Map of the preliminary works for the projected water supply of the industrial districts of Upper Silesia, scale $\frac{1}{8000}$, autographically printed on stone (M. Spiegel, Breslau).

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

Example of a special map for industrial use for marking projected railroads, waterways, &c. A reprint from the original survey map scale 1:8000.

3350. Map of the Industrial District of Upper Silesia, scale 1: 8000; autographic lithography.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (M. Spiegel, Breslau).

3351. Attempt towards a Petrographic and "Flötz" Map of the Waldenburg mountain district, drawn by the mining surveyor, Lange, in the year 1807.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

This map is of historical interest, as the first attempt to form a geological map representing the relations between important mining bands in the Waldenburg coal district. The scientific and technical observations appear, even at the present time, to be quite correct.

3352. "Flötz" Map of the Coalfields at Kohlau (now the Consolidated Abendröthe Mine), drawn by the mining surveyor, Schultze, in the year 1804.

Royal Prussian Upper Mining Court for the Provinces of Silesia, Posen, and Prussia (Breslau).

A map some years older than the preceding.

3353. Five Interesting Sections of large **Basalt Quarries.**

Mineralogical and Geological Cabinet of the School of Industry, Cassel (Dr. H. Möhl).

SECTION 17.—MINERALOGY, CRYSTALLOGRAPHY, &c.

West Gallery, Upper Floor, Room M.

I.—APPARATUS, INSTRUMENTS, &c.

a. Blowpipe Apparatus, &c.

3422. Blowpipe Apparatus for determining minerals. Case as supplied to the Arctic Expedition. *J. R. Gregory.*

3423. Plattner's original Blowpipe.
Royal Mining Academy, Freiberg, Saxony.

3424. Complete Blowpipe Apparatus, according to Plattner, consisting of a large case, with balance, instrument case, &c., reagent case, charcoal box, balance case, and leather cover.
A. Lingke & Co. (*Max Hildebrand and Ernst Schramm*), *Freiberg, Saxony.*

3425. Cabinet of Apparatus and reagents, for blowpipe analysis. (Mineralogy.) *James How & Co.*

3426. "The Student's Pocket Blowpipe Case."
Thomas J. Downing.

This comprises the following necessaries, carefully selected for the student's use in the analysis of minerals: Blowpipe, candle, matches, charcoal, fluxes, acids, bone ash, mould for making cupel, anvil, hammer (handle loose), file, forceps, glasses for acids, streak plate, lens, platinum wire and foil, magnet, and glass tubes. Fitted in japanned tin case, with fastening, and adapted for the pocket.

3427. Collecting Bag for the geological and mineralogical collector. *Thomas J. Downing.*

3428. Mohs' Scale of Hardness. Nine minerals, with file, in strong case. *Thomas J. Downing.*

3429. Von Kobell's Scale of Fusibility. Six minerals, for determining the degrees of fusibility, in strong case.
Thomas J. Downing.

3430. Scale of Hardness.
Royal Mining Academy, Freiberg, Saxony.

3431. Collection of Minerals for Blowpipe experiments. *Royal Mining Academy, Freiberg, Saxony.*

3432. Illustrations of Metallic Incrustations produced by means of the blowpipe on charcoal, by Dr. Theodor Richter.
Royal Mining Academy, Freiberg, Saxony.

3433. Harkort's self-made Scale for measuring small Globules of Silver.
Royal Mining Academy, Freiberg, Saxony.

b. GONIOMETERS, &C.

3433a. Double-refraction Eyepiece Goniometer, for measuring angles of crystals in the microscope.
University of Oxford.

On the construction of the late Dr. Leeson, and given by Mrs. Leeson to the University of Oxford.

3434. Retort and **Geissler Tube,** used by Prof. Vogelsang in his experiments, proving the liquid contents of certain minerals to be carbonic acid.
Royal Polytechnic School, Delft, Prof. J. Bosscha.

3435. Wollaston's Reflecting Goniometer, with an arrangement for readily centering the crystal ; also a portable pair of adjustable bright signals, the spot being reflected from the crystal, and the line from a black mirror placed underneath it.
Charles Brooke, M.A., F.R.S.

3435a. Reflecting Goniometer, invented and used by Dr. W. H. Wollaston. Accompanying it are notes of some of his measurements of crystals. *G. H. Wollaston.*

3436. Wollaston's Reflecting Goniometer, belonging to and used by the late Rev. Dr. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge, when Professor of Mineralogy.
Rev. Nicholas Brady, M.A.

3437. Babinet's Goniometer, for measuring angles of crystals and refractive indices of liquids. For the latter purpose the liquid is placed in the hollow prism. *Frederick Guthrie.*

3438. Working Model of a new and simple form of **Reflection Goniometer,** very compact, and allowing the application of a vernier for exact measurement. *Prof. Jos. P. O'Reilly.*

In this model a spiral traced on a cylinder is substituted for the divided circle, as in the ordinary Wollaston. The measurements are given by the intersections of the spiral with a divided straight edge parallel to the axis of the cylinder and in contact with it.

See Plate accompanying notice ; Proc. Roy. Irish Acad., ser. II., vol. I., pl. XX. (The model represents the first form, since modified as in the plate.)

3439a. Simple Substitute for a **Goniometer.**
Prof. W. H. Miller, M.A., F.R.S.

By means of this a crystal can be measured by Wollaston's method, and the angle of an edge determined by measuring the angle between two lines drawn on paper along the wooden part of the instrument in its two different positions, by comparing the arc, intercepted by the two lines on a circle drawn through the point of intersection of the lines, with the whole circumference, by means of compasses.

3440. Goniometer, with additional pieces of apparatus, by which it may be converted into an instrument for determining refractive indices, and an instrument for measuring the angle between the optic axes of biaxial crystals.
University of Oxford.

3441. Contact Goniometer, being the instrument used by the Abbé Haüy. *University of Oxford.*

It was formerly in the collection of Haüy's minerals, acquired by the late Duke of Buckingham. His Grace presented it to Dr. Buckland, by whom it was placed with the collection of minerals belonging to the University of Oxford, in which Dean Buckland was professor of mineralogy and geology. The Dean's autograph is on the morocco case.

3442. Goniometer, with horizontal circles, and adjusting level.
Prof. Baron von Feilitzsch, Greifswald.

This reflective goniometer has a dividing circle of 7·5 inch diameter. The division runs direct as far as $\frac{1}{3}$°, and with the application of the vernier 0·5 minutes may be read. The instrument can likewise be used for spectrum experiments.

3443. Goniometer. *R. Fuess, Berlin.*

3443a. Goniometer. *M. Lutz, Pàris.*

3443b. Goniometer, Wollaston's. *M. Lutz, Paris.*

3443c. Goniometer, Babinet's. *M. Lutz, Paris.*

3444. Reflecting Goniometer, on marble slab, in mahogany case. *F. W. Breithaupt and Son (G. Breithaupt), Cassel.*

A reflecting goniometer of the most perfect and improved construction. The circle is 21 centimeters in diameter, divided on silver to 10′, the vernier giving readings to 10″, with lens, telescope, microscope, illuminating tube with prism, and arrangement for centering the crystals; also a lens for the objective of the telescope, &c. On a marble slab. Property of the K. K. Bergakademie of Leoben, in Styria.

3445. E. Mitscherlich's Goniometer.
Prof. A. Mitscherlich, Münden, Hanover.

A description of the goniometer is given in the memoir in "Berichte der königl. preussischen Akademie der Wissenschaften, 1843." E. Mitscherlich used this goniometer in much of his crystallographic work.

3446. Goniometer (made by Messrs. Powell and Lealand), with adjustments for mounting a crystal (as described in the introduction); and with fittings adapting it for the purposes, 1, of an instrument for determining refractive indices, and 2, for measuring the angle between the optic axes of biaxal crystals.
Prof. N. S. Maskelyne.

3446a. Goniometer, according to Börsch's principles; executed by Breithaupt and Son.
High School of Industry, Cassel (Dr. E. Gerland).

The goniometer—a deflecting goniometer, according to Babinet—can be altered into a spectrometer by affixing a prism. It has the advantage that all examinations and corrections can be ascertained without special auxiliary means, as well as all angles; refraction coefficients can be found by two entirely different methods. (See Börsch, Poggend. Ann., vol. CXXIX., p. 384.)

3447. Polarising Apparatus, with telescope tube and goniometer. *Wilhelm Steeg, Homburg, Prussia.*

3448. Brezina's Stauroscope.
Wilhelm Steeg, Homburg vor der Höhe.

3449. P. Groth's Universal Apparatus for Crystallographic Optical research. *R. Fuess, Berlin.*

Vide "Physikalische Krystallographie," by Professor P. Groth, Leipzig, Engelmann, 1876.

3450. "Microgoniometer," for measuring with the microscope. *Prof. Friedrich Pfaff, Erlangen.*

The arc which stands horizontally can also be placed so that it can be used for vertical measurements. A small pamphlet on the instrument accompanies it.

3451. Charles' original Goniometer.
Conservatoire des Arts et Métiers, Paris.

3453. Apparatus for studying and exhibiting the Optical Characters of Crystals. *M. Werlein, Paris.*

3454. Instruments of Observation.

Three prisms for demonstrating the different dispersions of axes in crystals.
Tourmalin pincers (Tourmalin or Lyncurium).
Andalusite pincers.
Prism of dense flint; Rossette substance.
Dichroïsmal lens.

M. Werlein, Paris.

II.—COLLECTIONS OF MINERALS, DIAGRAMS, MODELS OF CRYSTALS, &c.

a. ROCKS AND MINERALS.

3455. Microscopic Sections of rocks and minerals.
J. R. Gregory.

3456. "Explorer's Comparison Mineralogical Cabinet." *J. R. Gregory.*

3457. Rough Gems and Stones, 15 varieties, for comparison and testing. *Thomas J. Downing.*

3458. Specimens of **transparent** slices of various **Minerals** for the **Microscope.**
Royal Polytechnic School, Delft, Prof. J. Bosscha.

a. Specimens of minerals described in Prof. Vogelsang's work, "Die Philosophie der Geologie," Bonn, 1867, and depicted on Tables I. and III.

b. Specimens of crystallites described in "Archives Neerlandaises des Sciences Physiques et Naturelles," and depicted in Table VII. of Vol. V., and Table III. of Vol. VI., and in Prof. Vogelsang's posthumous work, "Die Kristalliten," edited by Prof. F. Zirkel, Bonn, 1875.

c. Quartz slices with cavities containing fluid carbonic acid.

3459. Thin Sections of Minerals.
Ludwig Möller, Giessen.

3460. Collection of rare and remarkable specimens of **Zinc Ores** from the north of Spain, and from the county Tipperary, Ireland, to illustrate the modes of occurrence and formation of hydrated silicates and carbonates, particularly the oolitic and imitative forms. *Prof. Jos. P. O'Reilly.*

3461. Photographs (4) of imitative shapes presented by certain hydrated silicates and carbonates of **Zinc** in the collection from the north of Spain. *Prof. Jos. P. O'Reilly.*

3462. Sections or Diagrams illustrative of **Zinc Ore** deposits of silver mines, county Tipperary, Ireland.
Prof. Jos. P. O'Reilly.

3464. Specimens of Minerals prepared for Observation.

Case containing minerals and chemical products.
Case containing specimen of micrographic rock.
Four cubes of different chroïtes crystals.
Rhomboïd in Iceland spar.
Section of a diorite.

M. Werlein, Paris.

3465. Collections of Crystals and Minerals.
B. Stürtz, Bonn.

3466. Collection of 200 separate Crystals, for mineralogical and crystallographical study; their faces have been crystallographically determined; the system of notation used is that of Naumann. *Bernh. Stürtz, Bonn.*

3467. Specimens from Mitscherlich's Collection of Artificially formed Minerals, Felspar, Magnetic Iron Ore, &c. *Prof. A. Mitscherlich, Münden, Hanover.*

3468. Specimens of Mica containing tourmalin, garnet, and quartz. *Max. Raphael, Breslau.*

3469. Collection of Plates of Crystals, Selenite, and Mica combinations, **Dichroiscope,** cubes and plates for showing dichroism; about 210 pieces in mahogany case.
Wilhelm Steeg, Homburg vor der Höhe.

In the collection of plates of crystals are a large number of beautiful, rare, and valuable minerals and chemical preparations, which in part show, besides polarisation figures, also dichroism, asterism, fluorescence, &c. Also preparations exhibiting interesting twin growths in closed crystals, and crystals containing liquids in cavities.

3469a. Russian Minerals taken from the educational collection in the Mining School in St. Petersburg. 417 specimens, value, 180*l.* *Mining School in St. Petersburg.*

1, 2. Gold. Zmeinogorsk, Altai.
3. Silver. Zmeinogorsk, Altai.
4. „ Salair, Altai.
5. „ Nikolaievsk, Altai.
6. „ Urjum, Siberia.
7, 8, 9. Copper. Nishni-Turünsk, Ural.
9*a*. Platinum. Nishni-Tagilsk, Ural.
9*b*. Iridosmine (Newjanskite). Zlatoust, Ural.
10, 11. Meteoric iron (Pallassite). Krasnoiarsk, Siberia.
11 *bis*. Tin. Yenisseisk, Siberia.
12. Aerolite. Pultusk, Sedletz.
13. Native sulphur. Kazan.
14, 15. Graphite. Serdobol, Finland.
16. Graphite. Ilmen mountains, Ural.
17, 18. Graphite. Tunkinsk mountains, Irkutsk.
19. Stibnite. Serentujevsk, Nertchinsk.
20. Molybdenite. Pitzaranta, Finland.
21. Molybdenite. Ilmen mountains, Ural.
22. Galenite. Zadonsk, Caucasus.
23. Tellursilver. Zavodinsk, Altai.
24. Bornite. Nishni-Tagilsk, Ural.
25. Sphalerite or Blende. Klitchkinsk, Nertchinsk.
26. Chalcosite. Olonetz.
27, 28. Chalcosite. Nishni-Turünsk, Ural.
29. Cinnabar. Ildikansk, Nertchinsk.
30. Pyrrhotite. Ersby, Finland.
31, 32, 33, 34. Pyrite. Pitkaranta, Finland.
35. Pyrite. Riazan.
36. Chalcopyrite. Beresovsk, Ural.
37. Jamesonite. Algatchinsk, Nertchinsk.
38. Pyrargyrite. Zmeinogorsk, Altai.
39. Tetrahedrite. Beresovsk, Ural.
40. Patrinite. Beresovsk, Ural.
41. Rock salt. Astrakhan.
42. Cerargyrite. Zmeinogorsk, Altai.
43. Embolite. Michailovsk, Orenburg, Ural.
44, 45, 46. Fluorite. Kadainsk, Nertchinsk.
47. Fluorite (Ratofkite). Iver.
48. Chiolite. Ilmen-mountains, Ural.
49. Cuprite. Nishni-Tagilsk, Ural.

50. Chalcotrichite. Gumeshevsk, Ural.
51. Hepatinery (Liver-ore). Nishni-Turünsk, Ural.
52. Minium. Michailovsk, Nertchinsk.
53, 54, 55. Corundum. Ilmen mountains, Ural.
56, 57. Corundum (Soimonite). Soimonovsk, Ural.
58, 59. Hematite. Gornoshitsk, Ural.
60. Hematite. Polekovsk, Ural.
61, 62. Ilmenite. Ilmen mountains, Ural.
63, 64. Perofskite. Achmatovsk, Ural.
65. Perofskite. Nicolai Maximilianovsk, Ural.
66, 67, 68, 69. Chlorospinel. Shishimsk mountains, Ural.
70. Magnetite. Achmatovsk, Ural.
71. „ Shishimsk mountains, Ural.
72. Magnetite. Lupiko, Finland.
73. „ Zlatoust, Ural.
74. Chromite. Ufaleisk, Ural.
75. „ Bilimbaievsk, Ural.
76. Chrysoberyl (Alexandrite). Katharinenburg, Ural.
77. Cassiterite. Pitkaranta, Finland.
78, 79, 80. Cassiterite. Onon, Siberia.
81. Rutile. Kossoi-Brod, Ural.
82. „ Sissertsk, Ural.
83. „ Sanarka, Miask, Ural.
84. Brookite. Kamenka, Miask, Ural.
85. Diaspore. Kossoi-Brod, Ural.
86. Göthite. Volk Ostrov, Olonety.
87, 88, 89. Limonite. Beresovsk. Ural.
90. Limonite. Orel.
91. Hydrargillite. Shishimsk mountains, Ural.
92. Bismuthite. Beresovsk, Ural.
93. Quartz (Rhombohedron). Volk-Ostrov, Olonetz.
94, 95. Quartz. Neviansk, Ural.
96, 97. „ Serapulka, Ural.
98. Quartz, with green Turmalin. Beresovsk, Ural.
99. Quartz (Yellow). Neviansk, Ural.
100. Quartz (Smoky). Neviansk. Ural.
101, 102. Quartz (Smoky). Mursinsk, Ural.
103, 104, 105. Amethyst. Lipovaia, Ural.
106. Avanturine. Tesma, Zlatoust, Ural.
107. Chalcedony. Kamtchatka.
108. „ Tshikoi, Nertchinsk.
109. Carnelian. Shilka, Nertchinsk.
110. Chrysoprase. Kishtym, Ural.
111. Heliotrope. Orsk, Orenburg.
112. Jasper. Korgon, Altai.
113. Jasper. Revnevaia-gora, Altai.
114. Jasper. Dutsharsk, Nertchinsk.
115. Opal. Kiev.
116. Tripolite. Simbirsk.
117. Wollastonite. Pargass (Ersby), Finland.
118, 119, 120. Diopside. Achmatovsk, Ural.
121. Baikalite. Sludianka, Baikal.
121 *bis.* Vanadoaugite (Lavrowite). Sludianka, Baikal.
122, 123. Rhodonite. Schabrovaia, Ural.
124, 125, 126. Pargasite. Pargass (Ersby), Finland.
127. Tremolite. Verchneivinsk, Ural.
128. Hokscharowite. Sludianka, Beikal.
129. Asbestos. Miask, Ural.
130. Sordawalite. Serdobol, Finland.
131. Pitkarantite. Pitkaranta, Finland.
132, 133, 134. Beryl. Mursinsk, Ural.
135. Beryl. Tigiretsk, Altai.
136. „ Adun-Tchilon, Nertchinsk.
137. Beryl. Ubrulga, Nertchinsk.
138. „ Onon, Siberia.
139. „ Tammela, Finland.
140. Emerald. Katharinenburg, Ural.
141. Chrysolite (Glinkite). Itkul, Ural.
142, 143. Phenacite. Katharinenburg, Ural.
144, 145. Phenacite. Ilmen mountains, Ural.
146. Helvine. Ilmen mountains, Ural.

147. Achtaragdite. Achtaragda (Wilui), Siberia.
148, 149. Grossularite. Wilui, Siberia.
150. Almandine. Taganai, Zlatoust, Ural.
151, 152. Garnet. Achmatovsk, Ural.
153. Garnet. Talaia, Siberia.
154, 155, 156. Melanite. Pitkaranta, Finland.
157. Melanite. Achmatovsk, Ural.
158, 159, 160, 161, 162. Zircon. Ilmen mountains, Ural.
163. Auerbachite. Masurenko, Ekatherinoslav.
164, 165. Malacone. Ilmen Mountains, Ural.
166. Vesuvianite. Lupiko, Finland.
167. Frugardite. Frugard, Finland.
168. Vesuvianite. Achmatovsk, Ural.
169. Vesuvianite (Perimorphose). Achmatovsk, Ural.
170. Vesuvianite. Poliakovsk, Zlatoust, Ural.
171. Vesuvianite. Medvedjeva, Zlatoust, Ural.
172. Heteromerite. Shishimsk mountains, Ural.
173. Wiluite. Wilui, Siberia.
174, 175. Epidote. Kumbakssa, Olonetz.
176. Epidote. Heposelga, Finland.
177. „ Sillböhle, Helsinge, Finland.
178, 179. Epidote. Achmatovsk, Ural.
180. Puschkinite. Verchneivinsk, Ural.
180 *bis*. Bucklandite. Achmatovsk, Ural.
181. Orthite. Werchoturie, Ural.
182, 183, 184. Uralorthite. Ilmen mountains, Ural.
185. Nephrite. Sludianka, Baikal.
186. Axinite. Kumbakssa, Olonetz.
187, 188. „ Berkutovaia-gora, Ural.
189, 190, 191. Steinheilite. Kisko, Oriervi, Finland.
192. Gigantolite. Tammela, Finland.
193. Pyrargillite. Helsingfors, Finland.
194. Mica (biaxal). Kimito, Finland.
195. Mica (biaxal). Alabashka, Ural.
196. Lepidolite. Schaitanka, Ural.
197. „ Serapulka, Ural.
198, 199, 200. Mica (biaxal). Ilmen mountains, Ural.
201. Fuchsite. Kossoi-Broel, Ural.
202. Diphanite. Katharinenburg, Ural.
203, 204, 205. Biotite. Sludianka, Baikal.
206, 207, 208. Wernerite. Laurinkari (Åbo), Finland.
209. Wernerite. Pargass (Ersby), Finland.
210, 211. Stroganowite. Sludianka, Baikal.
212, 213. Glaukolite. Sludianka, Baikal.
214. Elacolite. Ilmen mountains, Ural.
215, 216. Cancrinite. Ilmen mountains, Ural.
217. Sodalite. Ilmen mountains, Ural.
218, 219, 220, 221. Lapis Lazuli. Sludianka, Baikal.
222. Lepolite (Anorthite). Karis-Lojo, Finland.
223. Lepolite. Karis-Lojo, Finland.
224. Lindsayite. Kisko, Oriervi, Finland.
225. Labradorite. Oiamo, Lojo, Finland.
226. Labradorite. Urpala, Sakkiervi, Finland.
227. Labradorite. Rodomisl, Kiev.
228. Oligoclase. Turholm, Helsinge, Finland.
229. Oligoclase. Kyrkslatt, Esbo, Finland.
230. Oligoclase. Stansvik, Helsinge, Finland.
231. Oligoclase. Katharinenburg, Ural.
232. Albite. Nishni Tagilsk, Ural.
233. „ Mursinsk, Ural.
234. „ Alabashka, Ural.
235, 236, 237. Albite. Kiriabinsk, Zlatoust, Ural.
238, 239. Orthoclase. Alabashka, Ural.
240, 241. Orthoclase. Mursinka, Ural.
242, 243. Amazonstone. Ilmen mountains, Ural.

244. Orthoclase. Miakoticha, Altai.
245. „ (Sunstone). Sludianka, Baikal.
246. Adularia. Mursinsk, Ural.
247. Marekanite. Marekanka, Ochotsk.
248. Nefedjewite. Klitshkinsk, Nertchinsk.
249. Chonebrodite. Pargass (Ersby), Finland.
250. Tourmaline. Beresovsk, Ural.
251, 252, 253. Tourmaline. Mursinsk, Ural.
254. Tourmaline. Schaitansk, Ural.
255, 256. Tourmaline. Borstchevatchnoi, Nertchinsk.
257, 258. Tourmaline. Ubrulga, Nertchinsk.
259, 260. Tourmaline. Mursinsk, Ural.
261. Tourmaline. Gornoshitsk, Ural.
262. Tourmaline. Adun Tethilon, Nertchinsk.
263. Andalusite. Schaitansk, Ural.
264. „ Tut Chaltovi, Nertchinsk.
264 *bis*. Chiastolite. Argan, Nertchinsk.
265. Xenolite. Peterhoff, St. Petersburg.
266. Wörthite. Peterhoff, St. Petersburg.
267. Cyanite. Taganai, Zlatoust, Ural.
268. Cyanite. Kishtym, Ural.
269. „ Sanarka, Ural.
270. „ Kamenka, Ural.
271, 272, 273. Topaz. Mursinsk, Ural.
274, 275, 276. Topaz. Ilmen mountains, Ural.
277, 278. Topaz. Adun Tchilon. Nertchinsk.
279. Topaz. Bortstchevotchnoi, Nertchinsk.
280. Sphene. Pargass (Ersby), Finland.
281. Sphene. Achmatovsk, Ural.
282, 283. Sphene. Ilmen mountains, Ural.
284. Sphene. Kazatchia Datcha. Ural.
285. Staurolite. Taganai Zlatoust, Ural.
286. Laumontite. Petropavlovsk, Ural.
287, 288, 289. Dioptase. Altyn Tübeh, Kirghistan Steppe.
290. Chrysocolla. Nishni Turünsk, Ural.
291. Chrysocolla. Nishni-Tagilsk, Ural.
292. Asperolite. Nishni-Tagilsk, Ural.
293. Picrosmine. Miask, Ural.
294. Calamine. Taininsk, Nertchinsk.
295. Calamine. Klitshkinsk, Nertchinsk.
296. Prehnite. Schaitansk, Ural.
297. Apophyllite. Piterlaks, Wiborg.
298. Natrolite. Tchikoi, Nertchinsk.
299. Analcime. Kulinda, Nertchinsk.
300. Chabazite. „ „
301. Stilbite. Bielaia, Nertchinsk.
302. Talc. Itkul, Perm.
303, 304. Pyrophyllite, Beresovsk, Ural.
305. Cimolite. Alexandrovsk, Ekatherinoslav.
306. Pelikanite. Kiev.
307. „ Lupiko, Finland.
308. Serpentine. Nurali, Miask, Ural.
309. Pinite with chlorite. Shishimsk mountains, Ural.
310, 311, 312. Leuchtenbergite. Shishimsk mountains, Ural.
313. Kämmererite. Bissersk, Ural.
314, 315. Rhodochrome. Itkul, Perm.
316, 317, 318, 319, 320. Clinochlore. Achmatovsk, Ural.
321. Clinochlore (pseud. Ceylanite). Nicolai Maximilianovsk, Ural.
322. Kotschubeite. Ufaleisk, Ural.
323. Kotschubeste. Bilimbaievik, Ural.
324. Chloritoid. Kossvi-Brod, Ural.
325. Xanthophyllite. Shishimsk mountains, Ural.
326. Xanthophyllite. Nicolai, Maximilianovsk, Ural.
327, 328. Pyrochlore. Ilmen mountains, Ural.
329. Tantalite. Kimito, Finland.
330. Columbite. Pvio, Finland.
331, 332, 333. Samarskite. Ilmen mountains, Ural.
334. Mengite. Ilmen mountains, Ural.
335. Apatite. Pargass (Ersby), Finland.

336, 337. Apatite. Katharinenburg, Ural.
338. Talcapatite. Shishimsk mountains, Ural.
339. Pseudoapatite. Shishimsk mountains, Ural.
340. Apatite. Ilmen mountains, Ural.
341, 342. Moroxite. Sludianka, Baikal.
343. Lazur-apatite. Sludianka, Baikal.
344, 345. Pyromorphite. Beresovsk, Ural.
346. Mimetesite. Beresovsk, Ural.
347, 348. Monazite. Ilmen mountains, Ural.
349. Vivianite. Kertsch, Crimea.
350. „ Bargusin, Nertchinsk.
351. Libethenite. Nishni, Tagilsk, Ural.
352, 353. Pseudomalachite. Nishni, Tagilsk, Ural.
354. Dihydrite. Nishni, Tagilsk, Ural.
355. Planerite. Sissertsk, Tschernoia, Ural.
356. Hydroboracite. Caucasus.
357. Borax. Baikal.
358, 359. Wolframite. Adun, Tehilon, Nertchinsk.
360. Hübnerite. Baiiovka (Bogoriak), Ural.
361, 362. Scheelite. Pitkaranta, Finland.
363, 364. Vanadinite. Beresovsk, Ural.
365. Volborthite. Preobrashensk, Perm.
366, 367. Thenardite. Marmishansk, Altai.
368, 369, 370. Barite. Kusinsk, Ural.
371. Barite. Gasimurovsk, Nertchinsk.
372. Celestine. Archangel.
373, 374, 375. Crocoite. Beresovsk, Ural.
376. Vauquelinite. Beresovsk, Ural.
377, 378. Gypsum. Astrakhan.
379. Gypsum. Bugulma, Samara.
380. „ Tetushi, Kazan.
381. Alunite. Zaglik. Caucasus.
382. Brochantite. Gumeshevsk, Ural.
383. Brochantite. Zyrianovsk, Altai.
384, 385. Calcite. Ural.
386. Calcite. Mulina, Nertchinsk.
387. „ Volk-Ostrov, Olonetz.
388. Calcite. Pavlovsk, St. Petersburg.
389. Calcite. Tmatra, Finland.
390. Dolomite. Pargass (Ersby), Finland.
391. Dolomite. Katharinenburg, Ural.
392. Gurhofian. Orenburg.
393. Siderite. Ural.
394. Sperosiderite. Ural.
395. Smithsonite. Tchagirsk, Altai.
396, 397. Smithsonite. Kadainsk, Nertchinsk.
398. Aragonite. Nishni, Turünsk, Ural.
399. Cerussite. Riddersk, Altai.
400. „ Taininsk, Nertchinsk.
401. „ Kadainsk, Nertchinsk.
402. „ Ildikensk, Nertchinsk.
403. Witherite. Zmeinogorsk, Altai.
404. Malachite. Gumeshevsk, Ural.
405. „ Nishni, Tagilsk, Ural.
406. „ Beloussovsk, Altai.
407. Aurichalcite. Zavodinsk, Altai.
408. Azurite. Nikolaievsk, Altai.
409. „ Semenovsk, „
410. „ Zyrianovsk, „
411, 412. Mellite. Malevka, Tula.

3471. Collection of Crystals of Minerals. *J. R. Gregory.*

3472. Nicol's Prism, whose side is about 60 millimeters.
Wilhelm Steeg, Homburg vor der Höhe.

3473. Prism of Rock Salt, 50 × 60 mm.
W. Steeg, Homburg vor der Höhe.

3474. Lens of Rock Salt, 75 mm. in diameter, and 300 mm. in radius. *W. Steeg, Homburg vor der Höhe.*

3475. Plate of Rock Salt, 60 × 60 mm.
W. Steeg, Homburg vor der Höhe.

3476. Calcspar Rhombohedron, with glasses ground parallel and perpendicular to the axis. *Wilhelm Steeg, Homburg.*

3477. Calcspar Prism, with plane parallel to the axis.
Wilhelm Steeg, Homburg.

3478. Piece of Sulphur with large Crystals.
Prof. A. Mitscherlich, Münden, Hanover.

E. Mitscherlich by these crystals of sulphur determined the crystalline form of the sulphur from the molten condition, and discovered the dimorphism of sulphur.

b. MODELS AND DIAGRAMS OF CRYSTALS, ROCKS, MINERALS, &C.

3479. Diagrams and Microscopic Slides, demonstrating the structure of Bohemian Basalt.

1. Diagram representing the most important types of Bohemian Basalt. On six plates.

2. Diagram showing the most important types of Phonolite, Trachybasalt, Trachylitbasalt, and Melaphyr rocks. On four plates.

3. Two boxes containing 10 microscopical preparations of the above-mentioned rocks.

4. Professor Boricky's works on the Basaltic and Phonolithic rocks of Bohemia, with short explanation of the Melaphyr illustrations. *Dr. Emanuel Borricky, Prague.*

3480. Photograph of the Rittersgrün Meteorite.
Royal Mining Academy, Freiberg, Saxony.

3481. Wall Map of the Natural History of the **Mineral Kingdom,** by Dr. G. Seelhorst. *P. C. Geissler, Nürnberg.*

The wall map consists of coloured plates, which are mounted on linen, with a portfolio in which to keep the map when not hanging on a wall. The text is printed on both sides of the map. The map is constructed to fold up in the portfolio, as well as to hang on a wall, and consists of one sheet.

3482. Diagrams (four), or "épures," illustrative of **Applications of Descriptive Geometry to Crystallography,** viz.: two illustrating derivation of holohedral and hemihedral tesseral forms; and two showing construction of crystal projections from angular measurements and from crystallographic formulæ.
Prof. Jos. P. O'Reilly.

3483. Model, mounted with movable arcs and core, for demonstration of the fundamental forms in each crystalline system, and of the geometric method of derivation of the different holohedral and hemihedral forms from the fundamental one in each system.
Prof. Jos. P. O'Reilly.

The model possesses a movable core adapting itself to the six systems and rise of elastic cords to represent the intersections and edges of forms.

3484. Seven Wire Models representing the symmetry of five of the crystallographic systems (made by Mr. Sparrow, of the British Museum, for Prof. Maskelyne). *Prof. Maskelyne, F.R.S.*

These models represent the great circles in which the sphere of projection is intersected by the planes of symmetry characteristic of the different crystalline systems; each plane of symmetry being subdivided by a network of wires intersecting at distances proportionate to the parametral ratios of some crystal belonging to the particular system. They are—

I. The cubic system.
II. The hexagonal system represented—
  1. By quartz.
  2. By calcite.
  3. By tourmaline.
III. The tetragonal system represented by apophyllite.
IV. The prismatic system represented by barytes.
V. The oblique system.

3486. Series of Twelve Water-colour Drawings, illustrative of the **Optical Phenomena** seen in sections of **Minerals** cut perpendicular to the optic axis or axes of the crystal under the influence of polarised light. Drawn by contributor.
Rev. Nicholas Brady, M.A.

PYRAMIDAL AND RHOMBOHEDRAL SYSTEMS.—UNIAXAL.

1. Calcite, negative, plane polarised, analyser and polariser, parallel.
2. „ „ „ „ 45° apart.
3. „ „ „ „ 90° „
4. „ elliptically polarised „ 45° „
Axis of $\frac{1}{4}$ wave film inclined about $22\frac{1}{2}$° to plane of polariser.
5. Quartz rotary polarisation. Analyser and polariser. 90° apart.
6. Two similar plates of quartz superposed, the lower showing left-handed rotary polarisation, the upper right-handed analyser and polariser, 90° apart. This phenomenon is known as *Airy's spirals*.
7. Quartz, circularly polarised, analyser and polariser, 90° apart, and axis of $\frac{1}{4}$ wave film 45° from plane of polariser.

PRISMATIC OBLIQUE AND ANORTHIC SYSTEMS.—BIAXAL.

8. Nitre, plane polarised, analyser and polariser, parallel line joining optic axes = to polariser.
9. Nitre plane polarised analyser and polariser, 45° apart, line joining optic axes 45° from polariser.
10. Nitre plane polarised analyser and polariser, 90° apart, line joining optic axes 45° from polariser.
11. Nitre plane polarised analyser and polariser, 90° apart, line joining optic axes parallel to polariser.
12. Aragonite optic axes, widely separated, only one is seen, analyser and polariser, 90° apart, line joining optic axes parallel to polariser.

3487. Large Wire Model, containing one example of each species of simple form in the cubic system of crystallography, with its corresponding hemihedral forms inscribed within a sphere of the chief zone circles of the system. *Rev. Nicholas Brady, M.A.*

The coloured wires indicating the junction of the faces are painted as follows: Cube, vermilion; octahedron and tetrahedron, French blue; dodecahedron, emerald green; three-faced octahedron and 12-faced scalenohedrons, deep cadmium yellow; 24-faced trapezohedron and three-faced tetrahedrons, burnt sienna; four-faced cube and pentagonal dodecahedrons, violet carmine; six-faced octahedron and six-faced tetrahedrons and irregular 24-faced trapezohedrons, Schele's green. On the several zone circles are marked the position of all the poles of the chief forms of the cubic system, except those of most of the forms of h.k.l., or six-faced octahedron, which lie in the triangles made by the zone circles. This model contains more than 700 wires soldered together. Made by contributor.

All these above forms are shown in solid in their corresponding colours in the accompanying large series of models of the cubic system, and are drawn in plan and perspective on a series of diagrams similarly coloured.

The particular forms contained in this model are 100; 111; + and $-\kappa 111$; 110; 122; + and $-\kappa$ 122; 112; + and $-\kappa$ 112; 210; + and $-\pi$ 210; 531; + and $-\pi$ 351; + and $-\kappa$ 351; Miller's Terminology.

3488. Collection of Models of the Cubic System of Crystallography, to a scale of three inches for the circumscribing cube, made in cardboard, and painted according to their simple forms. *Rev. Nicholas Brady, M.A.*

These comprise all the chief varieties of the several species, both holohedral and hemihedral, together with the chief combinations of the principal examples of each simple form, with the cube, octahedron, tetrahedron, and rhombic dodecahedron, fully illustrating the passage of one combination to another. In this series the positive and negative hemihedral forms and their orientation are denoted by the dark and light tints of the same colour.

3485. Diagrams illustrative of the **Cubic System** of **Crystallography,** painted to match the models.

Rev. Nicholas Brady, M.A.

These give the general position on the sphere of projection of all the chief varieties of the species in the system. Examples of the different species, both holohedral and hemihedral, in orthographic perspective, in projection on the plane of the paper, and giving the position of their poles on the sphere of projection, with similar drawings for twin crystals, drawn by contributor.

3489. Collection of three-inch **Models** of the regular **Platonic Solids,** the only forms possible with equilateral sides, and equi-angular with the simple forms from which they are respectively derived. Made by contributor. *Rev. Nicholas Brady, M.A.*

3490. Set of Regular Octahedral Models, showing that crystalline form depends upon the number and parallelism of parts, and not upon the mere shape of the face. Made by contributor.

Rev. Nicholas Brady, M.A.

3491. Set of three-inch **Models** of the **Pyramidal System** of **Crystallography,** giving the chief simple forms of the minerals of the system, with the latitude of their poles. Made by contributor. *Rev. Nicholas Brady, M.A.*

3492. Collection of Models of the Rhombohedral System of Crystallography, with its holohedral, hemihedral, and tetrahedral forms, showing their orientation and combination with the form 111 written. Made by contributor.

Rev. Nicholas Brady, M.A.

3493. Large Models of Crystals, for lecture illustration.

Prof. Crum Brown, University of Edinburgh.

The models are made of pasteboard, and painted. Six models are sent—(1) Rhombic Dodecahedron, and (2) Pentagonal Dodecahedron, illustrating the relation of these forms to the cube; (3) and (4), Dextro and Laevo-tartaric acid; (5) Double laevo-tartrate of soda and ammonia; (6) Asparagine.

3494. Collection of 114 **Models of Crystals,** in wood.

Heinrich Piel, Bonn.

3495. Collection of 100 **Models of Crystals,** in wood, to illustrate the most important chemical compounds.

Heinrich Piel, Bonn.

3496. Complete collection of **Models of Crystals,** 300, in three boxes. *Heinrich Piel, Bonn.*

The whole of the collections of the models of crystals have been carefully prepared by hand, without the aid of machinery.

The models of these collections have an average diameter of section of 5 centimeters; if required, the models may also be procured of a section of 10 centimeters, by which the price would be proportionately increased. Besides complete collections of any desired size and number, single models may also be obtained, the price of which will depend on the number of faces and the difficulty of their manufacture. If desired, stands may be obtained. Stands may be procured for exhibiting the models in a position parallel with their axes. Each collection is accompanied by a catalogue containing, besides the name of the model, its form and its crystallographic symbol according to Naumann's—or also, if desired, according to Miller's—system; and, in addition to these, the most important minerals and chemical compounds which the models represent.

3498. Eighteen large **Diagrams of Crystals.**

Prof. G. vom Rath, Bonn.

These diagrams are manuscript drawings, and are used for the illustration of mineralogical and crystallographical lectures.

3499. Models of Crystals, made from glass plates.

W. Apel, Göttingen.

The large size of the models renders them especially useful for demonstration. The angles agree with those of the natural crystals, as exactly as the difficulty of manufacture will permit. The threads showing the axes have the same colour for similar axes, and a different colour for dissimilar axes. In the hemihedral forms the corresponding holohedral forms are included, and from the colours marked on them it can be seen whether they are disappearing or remain in the hemihedral forms. The hexagonal system is, according to Miller, referred to three axes cutting each other at oblique but equal angles.

3500. Models of Crystals, in wood and wire.

Royal Mining Academy, Freiberg, Saxony.

3501. Tables for Instruction in Crystallography.

Dr. F. Pfaff & Th. Bläsing's Library, Erlangen.

3503. Forms of the Isometric Systems, represented in all possible combinations. *Prof. Dr. Prestel, Emdem.*

3504. Skeleton of a Rhombohedron, with a divided side for crystallographic demonstration. *Albrecht, Tübingen.*

By the string placed round the dividing rods all the faces of the rhombohedral system, of which the indices of *h, k,* & *l* are represented by three of the number 0 to 5, can be illustrated. Compare Miller's Treatise on Crystallography, p. 55.

3505. Book, "Nephrit und Jadeit nach ihren mineralogischen Eigenschaften sowie nach ihrer urgeschichtlichen und ethnographischen Bedeutung." By Heinrich Fischer, Stuttgart, 1875. With 131 woodcuts, and two chromolithographs.
Prof. Leopold Heinrich Fischer, Freiburg, Baden.

In this book is originated a new branch of mineralogy, viz., the archæological and ethnographical. Hitherto the sculptures, amulets, and ornaments of stone in the museums have been looked upon as show objects, but as quite devoid of scientific interest.

The volume also serves as a guide to the series of models (in wax, gypsum, &c.) exhibited by Dr. Adolf Ziegler, of Freiburg, in Baden, of such scientifically important and prominent original sculptures from Asia, New Zealand, Marquesas Island, Otaheite, Central America, Mexico, Peru, &c. as are partly exhibited in the Freiburg Mineralogical Museum and the Freiburg Ethnographical Museum, and partly were lent by other museums to the Freiburg Museum for the preparation of models.

There can be no doubt that the presence of such models in the Archæological and Ethnographical Museums will be a great help to this branch of study, which has until now been quite neglected, but which promises to become of the highest importance in the study of the most ancient races of men; for the stone remains are indestructible proofs of past periods of civilisation.

The remains of sculpture, the archæological records of America and Oceania, so remarkable in their form and in the astonishing hardness of the minerals out of which they are made, and which have hitherto been neglected in Europe, will by means of these models become better known.

3506. Imitations of large and small **Amulets, Idols, Implements,** &c. of archæological and ethnological importance. Compare the work of Prof. H. Fischer, "Nephrit und Jadeit."
Dr. Adolph Ziegler, Freiburg, Baden.

These imitations (of different materials according to the characters of the minerals) were prepared, on the suggestion of Prof. H. Fischer, Director of the Ethnographical Museum of the University of Freiburg, and were used partly to preserve for the ethnographical collection of the University copies of the originals sent to Freiburg for exhibition, and partly for purposes of exchange. Professor Fischer says, in his new work on Nephrite and Jade, "I " had in Freiburg, Baden, the much-desired opportunity for the manufacture " of casts, as Dr. Ziegler, whose preparations in wax are deservedly valued " in the studies of anatomy and the history of evolution, has succeeded so " happily in the imitation in wax of the originals which I handed to him, " even to the extent of copying the original colours so exactly that it is difficult " to say, on looking at the two together, which is the original and which " the imitation."

A list of the different pieces is given with the imitations, containing references to Professor Fischer's work.

3507. Sohncke's Universal Model of the Raumgitter, made by Heckmann of Carlsruhe, for explaining the author's theory of the structure of crystals.

Appendages to the model :—

Key.
12 elastic spiral threads.
6 tin caps. *Prof. Sohncke, Carlsruhe.*

3508. Model of Octahedral "Raumgitter."
Prof. Sohncke, Carlsruhe.

According to Bravais the molecules of all crystals are so arranged that their centres of gravity lie in the intersection of three co-ordinates originating in parallel equidistant planes forming a grating in space, the so-called Raumgitter of the author, who has further shown that any unlimited regular system of points in space may be reduced to one or more parallel systems of this kind.

The model consists of a series of parallel tubular brass rods arranged as a cube, but which can be lengthened by sliding joints and their angles of intersection may be varied by hinged joints. The intermediate parallel gratings are represented by wires carrying wooden balls which can be shifted to represent the required position of the molecule. With it the 14 possible kinds of positions as defined by the author may be demonstrated.

For a complete description see the author's paper in Carl's Repertorium für Experimental Physik, &c., Munich, Vol. XII.

The universal model of the raumgitter has the object of bringing to view the 14 possible different kinds of Raumgitter or point systems of the parallelopiped form.

Its importance consists in the following points :—

(1.) According to Bravais the molecules of all crystals are arranged in a Raumgitter.

(2.) According to a theory of crystal structure, developed a short time ago by the exhibitor, the molecules are arranged according to regular systems of points, which latter are always composed of many Raumgitters placed in each other.

From this one model all Raumgitters can be derived; it is made so as to be movable. The dimensions can be altered by drawing out eight edges, after the manner of a telescope. Also, the globe must be divided in similar proportion to the edges.

For the purpose of altering the angles, each angle is provided with two joints, by means of one of which it is possible to incline the four unlengthenable edges, which are now vertical. The four horizontal edges must previously be placed parallel to each other.

Elastic threads are sent which can be stretched between different globes to show their lines of combination. The tin caps are used for indicating particular spheres.

The fixed model shows the octahedral Raumgitter; of course the movable model can be brought to this form.

3509. Case, containing **15 Models of the most important Diamonds,** made with Bohemian crystal glass, Koh-i-noor in former and present state, Regent, Pole Star, Orlow, Empress Eugenie, South Star, Nassak, Great Mogul, Tosseau, Piggot, Saucy, Shah of Persia, Hope, Pasha of Egypt.

Dr. Th. Schuchardt, Görlitz.

SECTION XVIII.—BIOLOGY.

South Gallery, Upper Floor, Room (N).

I.—MICROSCOPES AND ACCESSORY APPARATUS.

(*a.*) Microscopes of Historical Interest.

3510. Compound Microscope, invented and constructed about 1590 by Zacharias Janssen, spectacle-maker, at Middleburgh, Netherlands.

The Scientific Society of Zeeland, Middleburgh.

Galileo's Microscope, then called **Occhialino.** Only the little tube remains, the lenses are wanting.

The Royal Institute of " Studii Superiori," Florence.

Viviani, in his life of Galileo, and in the inscriptions which be placed upon his house in the Via dell' Amore in Florence, states that the first microscope invented and constructed by Galileo was presented by him to the King of Poland in the year 1612.

Prince Cesi, the founder of the Accademia de' Lincei in Rome, writing to Galileo in 1624, says—" that he had received the instrument lately made by " him (Galileo) for the observation of very small things, &c." And Imperiali, in a letter to Galileo, dated 5th September 1624, writes as follows :— " I have not words enough to thank you for the occhialino which you were " so kind as to send me. It is quite perfect, and has many most admirable " points, as indeed have all your inventions."

3511. Two Microscopes, by Jan van Musschenbroek, a Dutch mechanician (b. 1687, d. 1748).

Prof. Dr. P. L. Rijke, Leyden.

3512. Microscope, of silver, **used by Anthony van Leeuwenhoek,** the Dutch Philosopher (b. 1632, d. 1723), in his investigations, and probably constructed by him.

Prof. Dr. J. A. Boogard, Director of the Anatomical Museum, Academy of Leyden.

3527. Old Microscope, 1705, made by J. Marshall in London, with seven objectives, objective table, object stand of ebony ivory plates, two forceps, needle, and leaden channel. Property of His Highness Prince Pless, Castle Fürstenstein.

Prof. Poleck, The Breslau Committee.

3528. Microscope, by Musschenbroek, in leather case.

Royal Museum, Cassel (Director, Dr. Pinder).

The microscopes exhibited are the oldest in the collection of the Cassel Museum.

The microscope of Jan van Musschenbroek dates from the 17th century. It has been frequently described and represented in drawings. The University of Leyden possesses a similar one. This specimen was seen in 1709 by *Uffenbach* in the collection of Professor *Wolfarth* in Cassel.

3529. Two Microscopes, by Leutmann, in leather case.
Royal Museum, Cassel (Director, Dr. Pinder).

These are microscopes by (or after) *Leutmann*, as is shown by the drawing in *Wolff's* "Allerhand Nützliche Versuche," III. Bd., p. 291. *Harting* gives no drawing of these microscopes.

3530. Microscope, by Hartsoeker, in leather case.
Royal Museum, Cassel (Director, Dr. Pinder).

This microscope by *Hartsoeker* was invented before 1694. *Wolff*, who gives a description and drawing of it, makes no mention of *Hartsoeker* as being its inventor. It was found by *Uffenbach* in Professor *Wolfarth's* collection.

3531. Microscope, by Campani, in leather case.
Royal Museum, Cassel (Director, Dr. Pinder).

One of the microscopes by *Campani*, which Landgrave *Charles* bought in Rome.

Catadioptric Microscope of Amici.
The Royal Institute of "Studii Superiori," Florence.

Dioptric Microscope of Amici.
The Royal Institute of "Studii Superiori," Florence.

One of the two microscopes has, instead of an object-glass, a concave mirror exquisitely worked in metal; the greater enlargements are obtained by varying the ocular; the other has its stage (*porta oggetti*) rendered movable by means of two very delicate micrometrical screws, so that, in this way, it can also be used as a micrometer. Both are for horizontal vision; in the first instrument, the image of the object being reflected by a plane metallic reflector; in the second one, by a rectangular prism. Particular attention is due to the camera lucida which accompanies them, and to the various systems of illumination. Among the instruments of Amici existing in Florence is his great refractor, more than five meters in length, with an objective 29 centimeters in diameter, an excellent instrument. It could not be sent for exhibition on account of its size.

3526a. Microscope of Nobili.
The Royal Institute of "Studii Superiori," Florence.

3530a. Microscope of Amici.
The Royal Institute of "Studii Superiori," Florence.

3517. Grand Microscope, with solar reflector and appliances. Made by Benjamin Martin about 1740.
The Committee, Royal Museum, Peel Park, Salford.

The instrument stands on a massive brass tripod foot from the centre of which rises a triangular bar of gun metal with a cradle joint at the lower end in which is a tangent movement for the inclination of the instrument to any required angle. The body is attached to the bar by an arm which moves on its centre by a wheel and pinion, and is further capable of a backward and forward motion. The arm can be turned on its centre over the stage for the reception of single lenses, and the body is adapted for movement parallel to the bar by means of a rack and pinion giving motion to a tube sliding within another. The fine adjustment is effected by means of a fine rack and pinion at the object glass end of the body. The stage is capable of movement up and down the bar by means of a rack cut in the back of the latter and a pinion. It is a traversing stage with two pair of dovetail plates at the back at right angles to each other; it is moved by two screws with divided heads for the measurement of objects. The stage can also be made to rotate and there is a divided head and vernier for reading small angles. The instrument is provided with a mirror which is movable up and down the bar by a pinion, a condenser and forceps on stands, stage condensers and forceps, animalcule cage, and other ingenious apparatus. Quekett had probably not seen this instrument of Benjamin Martin's when he asserted that James Smith was the first in this country to make a microscope with traversing stage and quick and slow motion in 1826.

3525. Microscope used by P. Lyonet in his observations with respect to the Cossus ligniperda. *H. Ottmans, Amsterdam.*

These observations are described in his Treatise on the Anatomy of the Caterpillar, 1760.

3519a. Culpepper Microscope, made about 1790.
E. Russell Budden.

A compound microscope of the form contrived by Mr. Culpepper. It consists of a large external brass body, supported upon three scrolls fixed to the stage, which is supported on three larger scrolls screwed to a brass pedestal. A concave mirror is fitted to a socket in the centre of the pedestal.

3529a. Large Amici Microscope, with apparatus complete, by Chevalier. *The Royal Microscopical Society.*

3529b. Double Microscope, by Culpepper.
The Royal Microscopical Society.

3529c. Single Microscope, by Dolland.
The Royal Microscopical Society.

3529d. Mechanical Finger, for picking up minute objects, by Bailey, after Professor Smith's pattern.
The Royal Microscopical Society.

3529e. Double Microscope, by Marshall.
The Royal Microscopical Society.

3529f. Single Microscope, by Tulley and Sons.
The Royal Microscopical Society.

3529g. Spectacles (4 pair), used by the late Robert Brown in his botanical researches. *The Royal Microscopical Society.*

3529h. Single Microscope, by Lindsay, 1742.
The Royal Microscopical Society.

3529i. Large Solar Microscope, complete.
The Royal Microscopical Society.

3529j. Single Microscope, in silver, by Culpepper.
The Royal Microscopical Society.

3531a. The Martin Microscope.
The Royal Microscopical Society.

Said to have been made by the celebrated Benjamin Martin for Geo. III. It bears no date, but was probably constructed about 1770. For full description *see* " Williams, On the Martin Microscope," " Transactions of the Microscopical Society," vol. x., 2nd series. It has a triple eyepiece, the middle glass being almost a bull's eye, and insuring a very large field; the distance between the two upper glasses and the lower one can be adjusted by a rack and pinion varying the power. The original objectives range from 4 inches to $\frac{1}{10}$th focal length. Higher powers appear to have been added up to $\frac{1}{30}$th; and there are four high powers up to $\frac{1}{40}$ to be used without the compound body on a small arm which is provided.

It was supplied with an extensive collection of ancillary apparatus, only part of which is in the possession of the Royal Microscopical Society, by whom it was purchased at a sale of Professor Quekett's instruments.

It is remarkable for the variety of its adjustments, general beauty of workmanship, and for special contrivances for various objects of unusually large dimensions. There are, however, obvious faults of construction, interfering both with convenience and steadiness. Its highest optical powers do not produce a good definition of such an object as the scales of Podura easily displayed by very much lower modern achromatics.

3531b. Amician Reflecting Engiscope.
The Royal Microscopical Society.

This is fully described by Dr. Goring in " Micrographia," 1837. The principle is due to Amici; this particular form to Dr. Goring and Mr. Cuthbert, by whom it was made. The body of the instrument acts as an eyepiece. The narrow tube resembles a Gregorian reflector. A small inclined mirror receives the image of the object and transmits it to a larger one, which forms a magnified image viewed by the eyepiece. The various arrangements for different adjustments are well contrived, and the workmanship of considerable merit. Had not achromatic objectives been constructed, the reflecting engiscope would probably have maintained its ground.

3518. Old-fashioned Simple, Compound, and Solar Microscope combined; date about 1800.
Essex and Chelmsford Museum, Chelmsford.

Very perfect specimen of old-fashioned simple, compound, and solar microscope combined; presented to the Essex and Chelmsford Museum by the late J. Disney, Esq., F.R.S., about 50 years ago, believed to have been then old, and to have cost originally 40*l.*

This specimen affords a good example of the progress of mechanical construction. The movement for shading the mirror is so completely superseded as to be a novelty.

Though effecting one object well it has given way to more complicated motions adapted to many uses.

3519. Old-fashioned Solar Microscope; date about 1800. *Essex and Chelmsford Museum.*

Presented to the Museum by the late J. Disney, Esq., F.R.S., about 50 years ago.

3526. Achromatic Microscope, made in 1807 by Hermann van Deyl, in Holland, the first maker of true achromatic objective lenses for microscopes.

Prof. Buys-Ballot, Utrecht, Holland.

(See Harting, Das Mikroskop, iii., page 132, sqq., where this very microscope is described.)

3513. Wilson's Pocket Microscope, with three single powers, about $\frac{1}{4}$, $\frac{1}{6}$, and $\frac{1}{8}$ inch, and box of objects of an early period. *William Sykes Ward.*

3514. Pocket Microscope, for opaque objects, four powers in Lieberkuhns 1 in., $\frac{1}{2}$ in., $\frac{1}{4}$ in., and $\frac{1}{8}$ in. *William Sykes Ward.*

3515. Achromatic Microscope, by Oberhäuser, of Paris, with powers of an early period; fine adjustment, achromatic condenser, and a curious double movement stage.

William Sykes Ward.

3516. Compound Microscope, by Dollond, formerly belonging to Josiah Wedgwood, potter. It is not inclinable; provided with two movements; the stage is rude in mechanism. There are six object-glasses, frog-plate, and other appliances.

Robert Garner, F.R.C.S.

3520. Microscope used by Sir W. Hooker, and employed by him in describing the British Jungermanniæ, Musci exotici, &c. *J. D. Hooker, M.D., P.R.S.*

3521. Microscope used by Dawson Turner, and employed by him in describing the "Algæ" for the "Historia Fucorum." *J. D. Hooker, M.D., P.R.S.*

3522. Microscope which belonged to **Robert Brown,** and was employed by him in his various botanical researches.

J. D. Hooker, M.D., P.R.S.

3523. Copy of Microscope used by Louis Claude Marie Richard in the Analyse du fruit, made for Robert Brown.

J. D. Hooker, M.D., P.R.S.

3524. Large Microscope, made by S. Plœssl, of Vienna, in 1845. With screw micrometer and other accessory apparatus. (Property of Prof. F. Cohn.)

Prof. Ferd. Cohn, of the Institute of Vegetable Physiology in the University of Breslau.

This microscope of Simon Plœssl was used by Prof. F. Cohn in all his researches during the years 1845–1862, and affords a historical proof of the degree of perfection attained by microscope manufacturers 30 years ago, as, at the time it was constructed, it was considered one of the best instruments on the Continent.

3531c. Goring's Operative Aplanic Engiscope, described and figured in Pritchard's "Microscopic Illustrations," 1830. An early form of compound microscope mounted with ball and socket universal joint, oval plane mirror and 2 in. condenser beneath the stage, black box for opaque objects, forceps, &c.
John Spiller.

3531d. Slit and Prisms used in the first form of Spectrum Microscope. *H. C. Sorby.*

As shown by the woodcut exhibited, the slit was placed some distance from the microscope, and the prism fixed below the achromatic condenser, so that an image of the spectrum was seen on the object examined under the microscope, and the relative powers of absorption for different rays observed. This form of apparatus has been entirely abandoned for many years, and replaced by the exhibitor's direct vision spectrum eyepiece, exhibited by Mr. John Browning, and by the exhibitor's binocular spectrum apparatus, exhibited by Messrs. R. & J. Beck.

This apparatus is described in the exhibitor's paper in the "Quarterly Journal of Science," 1865, vol. ii., p. 198.

(*b.*) Microscopes by Modern Makers.

3532. Microscope; the first made on Joseph Jackson Lister's model, by James Smith, in 1839, but refused by the trade as being too great a departure from the old and approved model.
Joseph Beck.

3532a. Microscope with Large Compound Stand. Designed by Andrew Ross about 1832. With rotating stage and sub-stage added in 1851. $\frac{1}{12}$ inch objective of old form attached.
Ross & Co.

3532b. Microscope with Large Compound Stand on the Jackson slide principle. Designed by F. H. Wenham in 1873. With $\frac{1}{5}$ inch new patent objective attached. *Ross & Co.*

3532c. Microscope with Portable Folding Stand for travellers. Designed by F. H. Wenham in 1874. With 1 inch triple objective attached. *Ross & Co.*

3532d. Microscope with Portable Stand, with objective suitable for students. *Ross & Co.*

3533. Microscope, on the approved Jackson model, with a limb continued under the stage and planed out in one continuous groove to insure perfect concentricity of the optical and illuminating apparatus. Designed for and exhibited in the Great Exhibition of 1851. *R. & J. Beck.*

3533a. Microscope Stand, with modification of Jackson's limb, Wenham's binocular body, a concentric rotating stage, and Brown's iris diaphragm. *R. & J. Beck.*

3534. "The Educational Microscope." The first cheap microscope supplied with English object glasses. Prepared for and exhibited in the Paris Exhibition of 1855 by Smith, Beck, and Beck. *Joseph Beck.*

3535. "Universal Microscope." This instrument, made for the Exhibition of 1862, showed a new method of varying the object glasses and eyepieces without removing them, the mode of constructing a simple binocular body, and a loose lever as a slow motion. *R. & J. Beck.*

3536. "The Popular Microscope." The first cheap binocular microscope brought out in this country, in 1864. *R. & J. Beck.*

3537. "The Economic Microscope;" a working instrument when the binocular arrangement is not required. *R. & J. Beck.*

3538. "Darwin's Dissecting Single Microscope." *R. & J. Beck.*

3538a. Sorby's Binocular Spectrum Microscope, with his new apparatus for measuring the wave length of every part of the spectrum. *R. & J. Beck.*

3539. "Beck's Dissecting Single Microscope." *R. & J. Beck.*

3540. Stephenson's Erecting Binocular Microscope. *J. W. Stephenson.*

The primary objects of this microscope are, as the name implies, the erection of the image and the utilization of deep powers by the binocular. The binocular effect is produced by the use of two equilateral prisms, placed together at an angle of 4° 30′; the two edges in contact form a wedge by which the cone of light from the objective is divided, and, after internal total reflection, is laterally inverted. The divided pencil of light is then received on a plate of silvered glass at the polarising angle, the reflection from which completes the erection of the image. This plate, which is of black glass, rotates on its axis, the black side being instantly exchanged for the silvered side, when an analyser is required.

The advantages of this instrument are,—

1. The erection of the image.
2. The small angle (9°) at which the bodies converge, giving a convergence towards an imaginary point at a distance of 14 to 15 inches from the eye.
3. A horizontal safety stage, yielding to a slight pressure by the objective, with the bodies inclined at a convenient angle.
4. The immediate substitution of an analysing plate of black glass when polarised light is used.

5. Identity of illumination in each tube.
6. The use of the highest powers rendered possible by the projection of the prisms beyond the body of the instrument into the objective.

3540a. New Binocular Microscope. *Henry Crouch.*

This instrument has a concentric rotating stage provided with adjustments for centering to the highest powers that can be applied. The sub-stage is also of new construction, being detached from the stand by means of a horizontal slide, and leaving the space underneath the stage entirely clear for greater convenience in the use of ordinary oblique illumination.

3540b. Newly arranged Binocular Microscope. *Henry Crouch.*

This is of somewhat similar construction to the above, but not so expensively finished; with and without sub-stage.

3540c. New Premier Binocular Microscope for Botanical and Histological Work. *Henry Crouch.*

3540e. Students' Binocular Microscopes of Old and New Pattern. *Henry Crouch.*

New Educational Monocular for Botanical and Histological Work. *Henry Crouch.*

3541. Student's Microscope. *James How & Co.*

3542. Popular Binocular Microscope. *James How & Co.*

3543. "Educational Microscope." With two object glasses, two eyepieces, condenser, &c., in mahogany box. Suitable for biological, histological, and physiological research. *M. Pillischer.*

3544. "Student's" or "Educational Microscope." With three object glasses, three eyepieces, condenser, polarising apparatus, animalcule cage, stage-forceps, &c., in mahogany case. Suitable for clinical and biological research, &c. *M. Pillischer.*

3545. "New College Microscope." *James Swift.*

In this microscope the optical tube slides through a fitting lined with velvet for smoothness of action. The fine adjustment has direct central movement, and is so constructed as not to be deranged by constant use. The diaphragm is flush with the surface of the stage, thus leaving the tube-fitting free underneath for the use of apparatus, and, if required, the diaphragm can be used in conjunction with any of the stage accessories.

3546. "University Student's Microscope," in a cheap and efficient form, especially designed for medical and botanical students. *James Swift.*

3547. Crane Arm Binocular Microscope, with newly contrived concentric stage and adjustable object holder moving upon glass bearings. All the fittings of this microscope are made self-compensating for wear. *James Swift.*

3548. Student's Microscope in an alloy of German silver and aluminium. *James Swift.*

3550. Microscopes. *G. S. Wood.*

3551. Microscope with complex adjustments, searcher, and oblique condenser apparatus. *Dr. Royston-Pigott, F.R.S.*

This microscope is fitted with a peculiar hypocycloidal movement and traversing screws for very delicate observations. The condenser possesses wide rectangular movements combined with a unique oscillating oblique action for directing the minute image of a flame or the sun either directly or obliquely upon any desired point in the field of view, giving fine views of many difficult objects, and gorgeous diffraction phenomena with circular solar spectra. It is also fitted with Dr. Royston-Pigott's searcher for aplanatic images, by which much greater depth of focus is attained, and new powers of correcting chromatic and spherical aberration, by moving the searcher between the objective and the eye piece or ocular.

3552. Improved Microscope, with rotating body. *John Browning.*

This instrument is contrived so as to combine the advantages of the English with the continental models ; it is especially adapted for dissecting purposes, as the body rotates with the stage ; objects may be examined with any power without losing their centricity.

3553. Stephenson's Binocular Microscope. *John Browning.*

In this instrument, for the first time, the planes introduced by Mr. Stephenson for altering the direction of the ray, so that the microscope can be used with the stage in a horizontal position, have been introduced near the eyepiece in the separate bodies ; this arrangement will, it is believed, be found to possess considerable advantages. With Stephenson's binocular, objects may be examined with both eyes with the highest objectives.

3554. Microscope with Micro-Spectroscope. *John Browning.*

The micro-spectroscope is intended for the observation of absorption bands in the spectra of solids or fluids, either by reflected or transmitted light. The instrument exhibited contains Mr. Sorby's most recent improvements.

3555. Pocket or Field Microscope, with two achromatic object glasses, contained in a leather case, measuring $7 \times 3 \times 1\frac{3}{4}$ in. *John Browning.*

3556. New Portable Microscope. *John Browning.*

This powerful and complete instrument, fitted with a sub-stage, accessory apparatus, polariscope, &c., is contrived to fold on a hinged joint in such a manner that when set up it is the size of an ordinary microscope, but when closed, it packs in a case of which the outside measurement is $6 \times 6 \times 9$.

3556a. Field Naturalist's Microscope. *Washington Teasdale.*

The field naturalist's microscope was designed by the exhibitor specially to meet the difficulty of teaching, and making generally popular, the use of the microscope. Messrs. R. Field & Co., of Birmingham (makers of the Society of Arts prize microscopes), have undertaken to make and keep it for sale to the public, and to supply with each instrument a copy of the paper on "The Simple Microscope as an Educational Instrument," by W. Teasdale.

3557. Microscope Stand with Chain Movements, exhibited in 1851. *William Ladd & Co.*

Educational Microscope. Plain stage, with dividing English object glass 2-inch, 1-inch, ½-inch. In cabinet. *Edmund Wheeler.*

Educational Microscope, with mechanical stage, with 1-inch 15°, and ¼-inch 70°, English objectives; in cabinet. *Edmund Wheeler.*

Dissecting Microscope, 3 powers. *Edmund Wheeler.*

Dissecting Microscope, with glass stage and mirror, 3 powers. *Edmund Wheeler.*

Pocket Microscope, for collecting diatomaceæ, &c. *Edmund Wheeler.*

Pocket Microscopes, for botany, entomology, &c. *Edmund Wheeler.*

3557a. Polarising Microscope, large Des Cloiseaux pattern, capable of being placed either horizontally or vertically by means of a joint and clamp, with all requisite accessories for the complete study of the optical bi-refracting properties of natural or artificial crystals, such as a goniometer for measuring the distance between optical axes in air or in oil, at various temperatures; ice-pan for oil; copper stove with thermometers and spirit lamps; the microscope frame and Nicol polarising prism, both being movable by means of a rack and pinion. *M. A. Picort, Paris.*

3557b. Polarising Microscope, large pattern, with all requisite accessories, the body of the microscope alone being movable on the stand. *M. A. Picort, Paris.*

3557c. Polarising Microscope, small pattern, mounted vertically with a small goniometer for measuring the distance between axes in air. *M. A. Picort, Paris.*

3660. Microscope Stand, medium size (No. 1b in the exhibitor's catalogue), with rack and pinion for the coarse adjustment, and with rotation round a vertical as well as horizontal axis, with five eyepieces, and Abbé's illuminating apparatus. *C. Zeiss, Jena.*

OF THE UNIVERSITY OF

3661. Set of Objectives, from 30 millimetres to 0·7 millimetre focal distance, in all 21 pieces. Some with the correction for cover glass. The whole in case with lock and glass lid.
C. Zeiss, Jena.

This collection embraces a complete set of microscope objectives, as contained in the catalogue of the exhibitor No. 21, 1874. Some of them are furnished with an "adapter," so as to suit the length of the tube of English microscopes. The threads are those of the "Microscopical Society's screw."

3559. Large Microscope, suitable for any research, with rotating stage, and joint for inclining the body of the microscope.
R. Wasserlein, Berlin.

3560. Small Student's Microscope.
R. Wasserlein, Berlin.

3561. Microscope No. 1, combined with a photographic apparatus and accessories. *Seibert & Krafft, Wetzlar.*

3562. Microscope No. 3. *Seibert & Krafft, Wetzlar.*

3563. Microscope No. 5. *Seibert & Krafft, Wetzlar.*

3564. Microscope No. 7. *Seibert & Krafft, Wetzlar.*

3565. Complete Microscope, with Abbé's illuminating apparatus, magnifies from 20 to 1,100 diameters.
F. Schmidt and Haensch, Berlin.

3566. Microscope (specially adapted for mineralogical research), with polarisation apparatus. *Ernst Leitz, Wetzlar.*

Height of the instrument, 1 foot 3 inches.

There is an arrangement for turning the tube round the optical axis, together with the upper round stage, which is prepared (after the design and drawing of Professor Möhl of Cassel) with a graduated rim.

The under-stage carries the vernier, and is provided with a circular diaphragm, which, together with the polariser, is furnished with a convex lens.

The coarse adjustment is done by a rack and pinion, and the fine adjustment by a micrometer screw; with draw-tube, and plane and concave mirror with vertical and horizontal movement. An eyepiece micrometer, the cross lines of which can be easily used for estimating the angle of dichroism, and angle measurement, by holding the eye-piece fast and turning the stage on which the object lies. A revolving nosepiece for holding five objectives. Analyser for fixing to the eyepiece, with a graduated circle.

A calcspar plate placed between the eyepiece and the analyser serves for the stauroscopic examination of crystals; magnifying powers 60 to 2,800 diameters.

3567. Microscope, with nine objectives, four eyepieces, and other apparatus. *E. Leitz, Wetzlar.*

3568. Microscope, with three eyepieces and four objectives.
E. Leitz, Wetzlar.

3569. Microscope, with two eyepieces and four objectives. *E. Leitz, Wetzlar.*

3570. Microscope, with two eyepieces and three objectives. *E. Leitz, Wetzlar.*

3571. Microscope, with two eyepieces and three objectives. *E. Leitz, Wetzlar.*

3572. Microscope, with one eyepiece and two objectives. *E. Leitz, Wetzlar.*

These instruments are exhibited as specimens of accurate and elegant work, combining solidity and cheapness.

3572a. Microscope, large model, with arrangement for the study of rocks with polarised light. *A. Nachet, Paris.*

3572b. Microscope, with camera obscura, for photographing microscopic objects, arrangement of M. Aimé Girard. *A. Nachet, Paris.*

3572c. Microscope for demonstration, which can be passed from hand to hand in histological lectures. *A. Nachet, Paris.*

3572d. Portable Microscope. *A. Nachet, Paris.*

3572e. Binocular Microscope, producing at will the effects of the stereoscope and the pseudoscope. *A. Nachet, Paris.*

3572f. Microscope for the study of the cornea and of the pupil. *A. Nachet, Paris*

3572ff. Nachet's first form of Binocular Microscope. *F. Crisp.*

3572g. Nachet's later form of Binocular Microscope (both stereoscopic and pseudoscopic). *F. Crisp.*

3572h. Wenham's Binocular Microscope for high powers. *F. Crisp.*

3572i. Ahrens' Binocular Microscope, with double similar prisms. *F. Crisp.*

3572j. Ahren's Binocular Microscope, with prism of Iceland Spar (using the ordinary and extraordinary images). *F. Crisp.*

3572k. Holmes' divided Object Glass Binocular Microscope (the object glass being cut in halves and each half forming one of the images). *F. Crisp.*

3572l. Tolles' Binocular Eyepiece. *F. Crisp.*

3572m. Beck's Binocular Simple Microscope.
F. Crisp.

3572n. Nachet's Triocular Microscope. *F. Crisp.*

3572o. Nachet's "Grand Microscope renversé avec miroir argenté" (giving very large magnification from the long distance from object glass to ocular). *F. Crisp.*

3572p. Chevalier's Universal Microscope. *F. Crisp.*

3572q. Beale's Demonstrating Microscope. *F. Crisp.*

3572r. Brown's Pocket Microscope. *F. Crisp.*

3573. Microscope for Demonstration.
Prof. Recklinghausen, Strassburg.

The instrument is so made that it can be taken up in the hand like a telescope, placed against the window, and the light found by even an unpractised observer in a very short time. By using a condensing lens with the instrument, ample illumination is obtained; but faint daylight and even lamplight will suffice. The instrument can be conveniently used with a magnifying power of 400 diameters, especially as an arrangement (as in Hartnack's immersion systems) is fitted to the lower end of the tube and affords the most accurate adjustment.

The object is to demonstrate microscopic preparations to a large audience. This demonstration-microscope has this advantage over ordinary microscopes for demonstrations, that it can be passed quickly round a class. As the microscopic object under observation has to be vertical, it follows that the preparation must be mounted and the cover glass fixed, and moreover it must not float in a liquid.

The tube with adjustment stand is made by Hartnack and Pratzmowski, the apparatus for illumination and the table by Majer of Strassburg.

3574. Microscope, with a set of objectives and eyepieces, consisting of—

a.	Objective,	No. 5,	magnifies	184	to	506	times.
b.	„	No. 6,	„	220	„	612	„
c.	„	No. 8,	„	366	„	1,012	„
d.	„	No. 9,	„	458	„	1,266	„

R. Winkel, Göttingen.

3575. Microscope constructed specially for the examination of microscopic sections. *R. Fuess, Berlin.*

3576. Immersion Lens, with special contrivance for increasing the magnifying power from 300 to 1,000 times with the low eyepiece. *R. Winkel, Göttingen.*

3577. Microscope (small model), commonly used.
Dr. Hartnack, Potsdam.

3578. Small Microscope, specially suited for mineralogical researches. *Dr. Hartnack, Potsdam.*

3579. Large Microscope. *Dr. Hartnack, Potsdam.*

These instruments are sufficiently well known, and it is not necessary to bring forward their peculiarities, but the mineralogical microscope has been recently constructed, and the exhibitor requests mineralogists to direct their attention to it.

3579a. New Dissecting Microscope with three achromatic powers, support for arms, and rack focussing giving three movements. *Harvey, Reynolds, and Co.*

3580. Microscope for Dissecting, with forceps and plate for dissection, and simple Microscope with rod action.

Geneva Association for the Construction of Scientific Instruments.

The Geneva Association constructs three different patterns of microscopes. In the simplest form the focussing movement is worked direct by the hand acting upon a rod which supports the optical system, and which slides up and down through a groove. The light is given by a mirror placed below the stage. In the second pattern the focussing is effected by means of a rack. Lastly, in the third pattern, the most complete of all, a pair of forceps revolving around two rectangular supports is substituted for the plate. By this means an object can be successively examined on all sides, and without leaving the focus of the glass. The optical parts are the same as in the preceding.

The optical system of each of these microscopes is composed of three "Wollaston" doublets with inner diaphragms, of 1 inch, ½ inch, and ¼ inch focal distance, giving magnifying powers of 9, 18, and 36 times, for 25 cm. length of vision.

The Geneva Association supplies besides to those who require higher powers achromatic lenses of short focus, giving great clearness and light. An achromatic lens of 2 millimetre focus produces a magnifying power of 125 times with perfect clearness.

3558. Small Microscope, with a Cylindrical Clip for Objectives.

Geneva Association for the Construction of Scientific Instruments.

This pattern of microscope is at once strong and simple. The system of the cylindrical clip is as follows :—

The objective is not screwed into the tube, but is held by a spring against a carefully turned bearer. To remove the objective, it is sufficient to draw it away transversely after having lowered it so as to exert a pressure in the direction of the axis. The objective is more easily placed in position than removed. The advantages resulting from this arrangement are :

1. A great saving of time to the observer, changes of magnifying power being rapidly accomplished.
2. The mechanical centering of the objective is better than that usually obtained with the screw.

3581. Large Microscope, with Reversing Action, and cylindrical clips for objectives.

Geneva Association for the Construction of Scientific Instruments.

This instrument, of which the general construction is that of Ross' English microscopes, has the following arrangements:—It may be used in different positions, vertical, horizontal, or oblique, and is specially applicable to the photography of microscopic objects. The illumination is effected by means of a mirror carried by a system of jointed rods, which limits its movement to an arc, the centre of which is the object to be observed. The best illumination is thus quickly secured, the observer not having to regulate at the same time the focal distance of the mirror and its lateral distance from the axis of the microscope. The condenser is moved by means of a rack, which serves to regulate exactly the position of the diaphragm. The whole condensing system, turning around an eccentric axis, can be very rapidly modified.

The stage turns independently of the tube. The focussing is effected, for coarse adjustment, by means of a rack, and for fine adjustment by means of a milled screw acting upon the tube supporting the objective, by the intervention of a lever that lessens the amplitude of the movement.

The tube supporting the objective is carried by a spring which serves to prevent the objects being crushed, when by mishap the objective is lowered too quickly. The milled screw for focussing is used as well for the micrometrical measurement of objects under observation as for focussing in the use of the objective in photography.

The objective is not screwed on to the tube, it is only pressed by spring clips against a steel bearing adjusted with the greatest care. To take off the objective, it is sufficient to draw it away transversely by pressing in the direction of the tube of the microscope. The objective is fixed as instantaneously as it is removed. The advantages resulting from these arrangements are the following:—1st. A great saving of time to the observer. 2nd. A mechanical centring of the objective much more perfect than that obtained by a screw. The defects of centring being immediately discovered may be partly corrected. 3rd. There is the easy choice of the side of the objective that gives the best effect when the oblique illumination is employed.

3582. Microscope, with durable body, with rotating movement round its axis, fine adjustment by means of steel prism, condenser, polarising apparatus, magnifying power from 10 to 1,200 diameters. *W. Teschner (successor to Amuel), Berlin.*

3583. Microscope, with magnifying power from 20 to 1,000. *W. Teschner, Berlin.*

3587. Polarising Microscope, with movable body and prism. *M. A. Picort, Paris.*

3588. Polarising Microscope, with movable body. *M. A. Picort, Paris.*

3589. Picort Vertical Polarising Microscope. *M. A. Picort, Paris.*

3589a. Polarising Microscope, with lens for parallel light, and Nicol prisms for measuring the axes. *Laurent, Paris.*

The illuminating part which is used in the case of crystals of one and of two axes, that is to say, for converging light, can be removed by hand and replaced by a lens set in a ring; the whole objective part is also removed, and the apparatus is then used for parallel light. There is, moreover, the movable eyepiece for the sighting, and the flat tints are very uniform and bright. The field of view is very large, the two axes of the white topaz are seen. Compensation can be effected with a parallel or a perpendicular quartz.

3589b. Polarising Microscope on round foot.

L. Laurent, Paris.

Same model, but mounted knee-wise, upon a pillar with lengthening piece, and a tripod. This model can be placed horizontally and is then used for measuring the divergence of the axes of crystals, immersed in oil, heated, &c. For this purpose the small glasses at the objective and at the illuminator are removed, they are mounted so as to travel easily. The glass support is also removed and replaced by the tube that contains a Nicol. The distance between the two plates of the glasses of the objective and of the illuminator is 15 millimetres, which allows room for either an oil pan or a stove by means of a support bearing a divided dial (which is not exhibited). The principle is that of M. Des Cloizeaux, and the arrangement, especially for this last model, is due to the exhibitor.

3589c. Early Microscope. *John Waugh.*

3589d. Two Microscopes in cases.

W. Techner, 180, *Friedrich Strasse, Berlin, W.*

Polarising Microscope for projection.

L. Laurent, Paris.

Glass Sunk Cells for the microscope (4).

L. Laurent, Paris.

3590. Solar Microscope, with alum cell. *Laurent.*

Model, prepared for projections, at the request of M. Des Cloizeaux. It has already been used at the Sorbonne and at the Paris Museum.

The field of view has been made as large as practice allows, with especial regard to illumination. The gypsum and its variations through heat can be clearly seen. By the advice of M. Des Cloizeaux, the horizontal pincers have been replaced by vertical ones which are much more handy. An alum pan for stopping the greater part of the heat has also been added to the projection lantern, and it has then been possible to project platinocyanure of barium, and formiate of copper, without altering them.

3590a. Dr. Lionel Beale's Portable Microscope, for class purposes or for travelling. *Thomas Hawksley.*

(c.) Accessory Apparatus.

3591. Photographic Apparatus for the Microscope.

Seibert and Krafft, Wetzlar.

This apparatus can be connected to any microscope, which, for this purpose, is placed perpendicularly under the box in front of the apparatus, after which, in order to exclude unsuitable light, the cloth-bag, fitting tightly by means of a gutta-percha ring, is pulled over the tube. The adjustment of the picture is effected by means of the glass-plate contained in the box, which is provided with squares and the ocular-like microscope. The lines of the glass-plate must be placed downwards. The microscope is placed on the glass-plate, and regulated by the upper lens in such a manner that the lines can be seen plainly; thereupon the picture is inserted, the microscope being used as ocular. In this manner the picture is sure to lie exactly on the lower surface of the glass-plate; consequently also on the prepared plate to be inserted afterwards. By applying the illuminating apparatus the plane mirror of the microscope should be used, the arrangement of which is easily understood. The achromatic condenser, accompanying the apparatus, consists of three achromatic lenses, and fits to microscope No. 3 (No. 3562) in the Exhibition.

3592. Microscopic Apparatus. Series of the more important pieces of apparatus and object glasses now supplied for use with the microscope. *R. & J. Beck.*

3593. Object Glasses (4), showing the lenses before they are put into the cells. *R. & J. Beck.*

3593a. New Stand on the Continental Model, the diaphragm being provided with centering screws so that it can be adjusted to each objective as applied. *Henry Crouch.*

3593b. Microscope Objectives and accessory Apparatus. *Henry Crouch.*

Suited to the stand described above, and for microscopic work generally, and mounting apparatus and materials.

3594. Object Glasses, Apparatus, and Accessories used in the different branches of microscopical research. *M. Pillischer.*

3595. Microscope Lamp. *M. Pillischer.*

3542a. Microscope Lamp. *James How & Co.*

3542b. Tate's Air Pump. *James How & Co.*

3542c. Selection of Transparent Photographs, for the **Lantern,** illustrating lectures upon geology, consisting of sections of strata, groups of fossils characteristic of the various sedimentary formations, restorations of extinct animals, &c. *James How & Co.*

3595a. Fittings for Microscope. *M. Lutz, Paris.*

3596. Apparatus to be used with the Microscope, for securing perfectly central illumination, manufactured by Wood of Liverpool. *Rev. W. H. Dallinger.*

The object of the apparatus is to secure minute and delicate alterations in the position of the flame-image upon the mirror or prism, since it has been found by the exhibitor that perfectly central illumination can only be secured by having the image of the flame exactly under the optical axis of the sub-stage combination, after the latter has been made to coincide with the optical axis of the object glass. This will enable the microscopist to illuminate the whole field of a $\frac{1}{4}$-inch object glass through an aperture of $\frac{1}{100}$th of an inch in diameter. But it can only practically be done by a fine set of mechanical motions in rectangular positions giving perfect command of the position of the flame.

3597. Apparatus for Continuous Observation of Minute Organisms with the highest powers, by preventing evaporation of the fluid in which the organisms live.

Rev. W. H. Dallinger and J. J. Drysdale, M.D.

This apparatus was devised by Messrs. Dallinger and Drysdale for prosecuting their "Researches into the Life-History of the Monads." It is used upon the ordinary "mechanical stage" of the microscope, so as to admit of the continuous examination under the highest powers of the same drop of a putrefactive or other fluid without allowing it to evaporate. The glass cup to the right is to be filled with water. The capillarity of the linen carries over a constant supply of moisture; part of this linen is included in the central cylinder into which the object glass projects, and the water thus constantly carried into this air-tight chamber causes the air therein to become so saturated that evaporation from the fluid under examination cannot take place. The highest powers may be used, because the india-rubber diaphragm yields instantly to the screw of the "fine adjustment."

3598. Microscopic mounting materials and dissecting instruments, consisting of:—

Wood-cutting instrument and chisel, instrument for cutting circles of thin glass, glazier's diamond, writing diamond, cell-making instrument, brass table and lamp, Page's forceps, case of dissecting instruments (containing four knives, two hooks, two points, three pairs of scissors, three pairs of forceps, and needle-holder), Valentin's knife, 1 oz. thin glass, 9 doz. slips (3 in. by 1 in.), 3 doz. wooden slips, 3 doz. cells, 200 labels, 5 capped bottles (containing Canada balsam, asphalte, gold-size, glycerine, and marine glue), bottle of Deane's medium, three stoppered bottles for containing chloroform, nitric acid, and liquor potassæ. *R. & J. Beck.*

3603. New Sub-stage Condenser, comprising achromatic condenser of high angle of aperture. *James Swift.*

The above is an effective spot lens, from 3 inch objective to $\frac{1}{6}$ inch; it has centering adjustments, contracting diaphragm, and complete polariscope, in which all the colours of the rainbow can be obtained. It also forms a complete substitute for every piece of apparatus used under the microscope.

3604. Low Angle Objectives. A series from 1 inch to $\frac{1}{8}$ inch. *James Swift*

3605. Popular Achromatic and Tinted Condenser.

James Swift.

This apparatus combines the achromatic condenser, light modifier, spot lens, and polariscope.

3606. Microscopic Objects, illustrating every department of microscopy.

Machine for cutting sections, with knife.

Improved turn table.
Hot plate and lamp.
Spring compress, and spring clips.
Instrument for cutting circles in thin glass.
Glass slips and thin glass covers.
Labels for covering and naming objects.
Buff block for cleaning covers.
Centering card.
Case of dissecting instruments.
Knives, forceps, needles, &c.
Syringe and appliances for injecting.
Small air pump for mounting.
Lamp for microscope, with white cloud reflector.
Bottles and dipping tubes for collecting materials.
Collecting bottle, net, hook, and jointed rod.
Cements, varnish, liquids, and media for mounting.
Boxes, cases, cabinets, for finished objects.

Edmund Wheeler.

3606a. Micrographic Study of Paper Manufacture.

M. Aimé Girard, Paris.

3606b. Collection of Microscopic Slides.

John Waugh.

3607. Instrument for verifying Micrometers of Microscopes.

W. F. R. Suringar, Leyden.

Consists of a metallic frame, resting at each side upon four pillars fixed in a wooden stand through which pass three screws, two at the one side, one at the other side, for regulating the horizontal position of the instrument. Upon the frame slides another, the quick movement of which is regulated by a rack and pinion, and upon this a third, destined for bearing the scale, with slow motion, directed by an adjusting screw with milled head. For using the instrument, put the scale, divided into a certain number (fig. 35) of millimeters on the inner slide, or (in the case of microscopes with very small stage, such as the small Oberhäuser-microscope now shown), on the three extra supports on the outer side, regulate the screws of the small additional table destined for bearing the microscope, in such a manner that the stage of the microscope glides under the frame, and the divisions of the scale can be centered with the field of the microscope. After having adjusted the ends of the eyepiece micrometer in the microscope to the ends of the stage micrometer that is to be verified, seen through the microscope, place the microscope over the middle part of the instrument, move the scale till the first division of the scale can be seen in the field of the microscope, adjust and measure the first division, and subsequently all the others, taking care to measure always from the same side (*e.g.* the left) of the lines. Notice the number of entire divisions of the eyepiece micrometer, and note the tenth part of them, to which each division of the scale corresponds. After having measured them all, one by one, make the addition, and divide the amount by the number of divisions measured. The quotient indicates the mean value of each division of the scale expressed in parts of the eyepiece micrometer, viz., of the millimetre of the stage micrometer. This quotient, divided into one, expresses the exact value of the millimetre to be verified in parts of the scale used for comparison, and itself previously compared with a standard scale. The accuracy obtained is proportional to the square root of the number of divisions compared one by one, and can be relied on to the $\frac{1}{1000}$ part of a millimetre.

The instrument should be placed before a window, and at a distance not exceeding six feet from it, because otherwise the scale would not receive sufficient light for seeing the divisions clearly through the microscope.

A description of verifications made by the instrument, with cut, accompanies it.

3608. Apparatus for Microscopical Research in the open air. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3609. Re-agents for Microchemical Researches, in box. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3610. Instruments for Microscopical Researches. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3611. Instruments for Microscopical Researches on living organisms, adapted to their observation when under the influence of various gases and at different temperatures. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3612. Drawings illustrating preceding Apparatus. *Prof. Dr. Leonard Roesler, Klosterneuburg.*

3615. Kratometer for finding magnifying power and focal length of objectives. *Dr. Royston Pigott, F.R.S.*

This simple instrument is so contrived that whatever object glass is used, the actual power is ascertained at once, whatever be the length of body employed. A stage micrometer of lines ruled to 100ths and 1,000ths of an inch is viewed by the kratometer eyepiece, and the number of divisions of the stage micrometer embraced by ten of the kratometer, gives exactly the magnifying power, if multiplied by ten. This instrument at once determines the focal length and comparative powers of all object glasses submitted to this test.

3616. Microscopic Refractometer, for ascertaining the mean refractive index of plates of glass or lenses. *Dr. Royston-Pigott, F.R.S.*

A new refractometer for determining the refractive index of white light (or mean rays or line E in the solar spectrum) of small plates or lenses of refracting material. The instrument measures to the 100,000th of an inch, the thickness of a thin plate as covering glass ·004″ thick, and the distance which an image is refracted upwards.

A minute prism reflects the light through a small plano-convex lens fixed at the end of the measuring screw ; the prism is illuminated by solar or artificial light by a condenser, and reflected up the axis of the microscope. Differential toothed wheels measure the number of revolutions of the screw (nearly 100 threads to the inch), and indicators give the 100ths, 1,000ths, 10,000ths, and 100,000ths of an inch. The instrument detected 32 changes of colour in Newton's rings of contact between the central black spot in air, caused by a film half a millionth of an inch thick, and the last vanishing colour on separating the plano-convex lens from a plane surface with which it had been in contact. It has measured the refractive index to three places of decimals in thin flint glass 0″·0042 thick.

3616a. Sorby's Standard Interference Scale, for measuring the position of absorption-bands in spectra.
R. & J. Beck.

3616b. Sorby's Volute Diaphragm, for regulating the amount of light for the spectrum microscope. *R. & J. Beck.*

3617. Early Form of Machine, with Knife, for making microscopical sections of wood, &c., devised by Andrew Pritchard, F.R.S.E., prior to 1835. *Dr. Urban Pritchard.*

The block of wood for section, if large enough, is fixed in the movable triangular chamber by means of the little screw. The larger screw at the bottom gradually elevates the whole, and the knife, held in both hands, shaves off thin sections as the wood is raised. Should the piece of wood be too small to be placed in the triangular chamber, it must be glued on to a block of convenient size.

The whole machine is made to screw on to a bench.

3613. Freezing Apparatus. A simple form for preparing soft tissues for microscopical examination, consisting of a solid copper cylinder with wooden handle and felt cap to fit over cylinder. *Dr. Urban Pritchard.*

Mode of use :—Immerse cylinder in mixture of ice and salt for a few minutes; then remove and wipe, place tissue to be cut, after being moistened with gum, on metallic end. Put felt cap over cylinder; tissue will be frozen and ready for cutting in two or three minutes.

3614. Glass Microtome for microscopical sections of hardened or frozen tissues. *Dr. M. E. Mulder, Groningen.*

The hardened tissue, previously imbedded in a cylindrical mass of wax,
consisting of a mixture of Stearine - - - 30
Hogs' lard - - - 24
White wax - - - 16
is introduced into the glass tube of the microtome, which is polished at its upper margin.

Any rotation or movement of the wax cylinder, which is exactly of the same size as the tube, is prevented by the four pins. The wax cylinder can be moved up or down by means of a screw, and sections are made by passing a knife over the polished surface of the tube.

The thickness of the sections is indicated by the lines on the screw. (Every line is $\frac{1}{50}$ mm.)

When the microtome is used for freezing, the glass tube is unscrewed and replaced by the freezing box. The tissue, imbedded in a solution of gum arabic, is frozen by filling the freezing-box with snow or ice and salt.

3618. Apparatus for maintaining an even Temperature in Microscopic Observations.

Geneva Association for the Construction of Scientific Instruments.

This instrument is intended for performing microscopic operations in a perfectly even temperature by means of hot water circulation. A small spirit lamp is placed under the reservoir at the extremity of the apparatus. A thermometer placed inside the instrument serves to regulate the temperature.

3619. Camera for Microscope.

Geneva Association for the Construction of Scientific Instruments.

3620. Two Ross Compressors, for the Microscope. (Ordinary models.)

Geneva Association for the Construction of Scientific Instruments.

3621. Compressor, by Schick, for the Microscope. (Ordinary model.)

Geneva Association for the Construction of Scientific Instruments.

3622. Microtome, with inclined plane for producing microscopic sections of extreme tenuity and regularity.

Geneva Association for the Construction of Scientific Instruments.

3623. Microtome by Professor Wilhelm His.

Geneva Association for the Construction of Scientific Instruments.

Many instruments for making microscopic sections exist, but most of them have been distrusted by scientific men. This distrust was more or less justified by the imperfection of the apparatus known hitherto, and it was mostly preferred to operate simply by hand, without its being possible to calculate with positive accuracy the thickness of the section.

During the course of his studies upon vertebrated animals, Professor W. His, of Basle, found the absolute need of an instrument for rapidly effecting sections of positive uniformity in thickness.

It is from his suggestions that the Geneva Association for the Construction of Scientific Instruments has constructed a Microtome, which has now the complete approbation of the scientific men who have had occasion to use it.

The requirements were: 1, that the knife should be directed very securely while remaining independent of the apparatus; 2, that the object to be sliced should be movable in a parallel line under the knife, and that the amount of the displacement should be read with great accuracy; 3, that the object should be fixed firmly in any position.

The instrument consists of a table, 75^{mm} long and 60^{mm} wide, capable of being inclined at will upon its foot. The table has a small tongue which is movable in parallel line by means of a micrometric screw indicating $\frac{1}{100}$ths of a millimetre. To the tongue is affixed a stay, having a tightening screw, under which is placed the object to be sliced. Above the table is a kind of steel arch bearing a plane, perfectly adjusted, perpendicular to the table. It is upon this surface that the knife, of which one side is also adjusted with the greatest care, is made to slide by hand.

3624. Professor Vogelsang's Apparatus, serving to **raise** the **temperature** of **Microscopic Objects.**

From the Collections of the Royal Polytechnic School at Delft, Prof. J. Bosscha.

By this instrument it was shown that the air bubble in the liquid carbonic acid contained in quartz crystals ceased to be visible at a temperature of about 32° C. (Poggendorff's Annalen, vol. 137, table III., fig. 2.)

3625. Parallel Compressor, with micrometric screw, specially intended for the study of ova, and for observing the development of lower organisms.

Geneva Association for the Construction of Scientific Instruments.

The upper cup takes off to admit the dissecting trough. The pressure is effected by means of the side adjusting screw. By moving the dissecting trough with the hand a round body can be examined on all sides successively.

The dissecting trough can hold a good quantity of water, of which no portion comes in contact with the metal, a favourable condition for the preservation of live organisms.

3626. Dr. Burdon Sanderson's hot or cold Stage, for use with microscope, and with arrangement for heating by gas, hot water, or lamp. *T. Hawksley.*

3626a. Boiler with incubating cells. *T. Hawksley.*

3627. Freezing Machine for making microscopic sections, by Professor Rutherford. *T. Hawksley.*

3628. Saccharometer, as accessory to the large microscope, from the same contributor. *R. Wasserlein, Berlin.*

The saccharometer is to be regarded as an accessory to the stand of the microscope. By this combination of two instruments (as the saccharometer can be fitted to smaller stands) cheapness is attained. The chief aim of the maker is to furnish a useful instrument, which at the same time shall be specially suited to the wants of the medical chemist in estimating grape sugar (as in diabetes). For this purpose the scale of the instrument is graduated so as to indicate in whole numbers and tenths the per-centage of grape sugar. For other substances a calculation is necessary.

3629. Woolmeasurer, fitting into the Student's Microscope. *R. Wasserlein, Berlin.*

This woolmeasurer, constructed by the exhibitor, is made at the express wish of Mr. Bohm, woolfactor at Leipzig. It affords the investigator the possibility of a complete command over stuffs composed of vegetable or animal fibres, as wool, silk, and all vegetable fabrics, so that they can be stretched and extended under the microscope; also in case the fibre is twisted, as in wool, it may be evenly stretched and rotated, so that its average diameter may be estimated. The apparatus allows the object which is thus stretched to be placed on a glass slide, so that it can be treated with acids, &c., and covered with a cover glass. All this can be done without preventing the manipulation described above. Threads up to a length of 1½ inch can be moved successively across the field of the microscope.

3630. Small Microtome, with an arrangement for the vertical elevation of the objects. *F. Süss, Marburg.*

3631. Larger Microtome, for the section of the spinal cord, with vertical elevation and divided circle. *F. Süss, Marburg.*

3632. Quadrant Microtome, for making microscopical sections at any given angle, with an arrangement for measuring the angle, and scale for showing the relative thickness of the section.
F. Süss, Marburg.

3633. Large Microtome, for cutting sections of the brain.
F. Süss, Marburg.

These microtomes are suited for embedding preparations. Samples of embedding preparations (soap mixtures), with instructions as to the use of the instruments, as well as the composition of the soap mixtures, are placed with the microtomes.

3634. Large Schiefferdecker's Microtome, with plate, two knives in case, glass bell jar, and brass mould for fixing preparations in an embedding mass. *F. Majer, Strassburg.*

3634a. Microtome. *Dr. Gasser, Marburg.*

This adaptation of the large Gudden microtome has been designed for embedding. The object and the enclosing mass being held fast by the screw at the top of the piston, and the often-condemned defect of repeatedly melting down in the case of large objects is avoided. The cylinder is slightly narrowed towards the top, in order that the object may more surely resist the knife which is guided by the hand on a polished steel surface. The instrument can be employed with any suitable liquid in the bowl, which can afterwards be drawn off through a gutta-percha tube, and the object being slightly screwed down, may be covered with a glass slide as a protection against drying up. In this way operations on the same object on several successive days may be carried on. The cylinder is of larger size than in the largest Gudden instrument, but can be further enlarged, if necessary, so as to enable sections of the entire human brain to be made.

3634b. Freezing Microtome, for enabling the microscopist to make thin slices of soft tissues. Invented by Professor Rutherford; made by the exhibitor. *Gairdner.*

The freezing microtome was devised by Professor Rutherford for the purpose of enabling the microscopist to make thin sections of soft tissues and organs. The tissue is placed in the well; a strong watery solution of gum arabic is poured around it, and a freezing mixture of ice or snow and salt is placed in the box. The sections are made with an ordinary razor. A full description is given in Rutherford's "Outlines of Practical Histology." (Churchill, London, 1875.)

3635. Smith's Microtome, modified by Schiefferdecker.
F. Majer, Strassburg.

3636. Brass Mould, for fixing preparations in an embedding mass. *F. Majer, Strassburg.*

3637. Microscopical Cutting Apparatus, for soft objects.
Prof. Jessen, Eldena, Pomerania.

3638. Fluid for keeping Parts of Plants, and preserving their colours in glass vessels.
Prof. Jessen, Eldena, Pomerania.

3639. Warm Moist Chamber, for observing microscopical objects at an elevated temperature during long periods of time. (Exhibitor's construction.)

Prof. Dr. Ferd. Cohn, of the Institute of Vegetable Physiology in the University of Breslau.

The apparatus in question combines the advantages of the moist chamber and the warm stage of the microscope. The object is laid in a drop of water on the underside of the glass plate in the centre of the cover, which has been previously removed; the cover is then firmly fixed, and the whole apparatus placed on the stage of the microscope.

It is warmed to the desired temperature, which is indicated by a thermometer, by means of a small gas flame placed underneath the descending heating tube. The object is observed through the glass plate in the cover, which takes the place of a cover glass. By regulating the flame, the temperature in the chamber, which is kept moist by the drop of water which cannot evaporate, can be maintained perfectly constant for a long time, and the development of microscopical organisms at a high temperature can be observed.

3640. Two Cases of Microscopic Objects.

Voigt & Hochgesang, Göttingen.

3640a. Cases of Microscopic Preparations. *F. Enock.*

3641. Microtome with Preparations, made by W. Apel, mechanician to the University of Göttingen.

Prof. W. Krause, Göttingen.

This microtome is accurately described by Prof. Krause in Waldeyer's and De la Valette's Archiv für microscopische Anatomie (earlier in Max. Schultze's Archiv), 1875, vol. XI., p. 216, plate XIII. It cuts in a purely mechanical manner, more by drawing than by pressing the knife, whilst any shifting either of the preparation or of the cutter by the hand is excluded by the principle of the construction of the microtome. The thickness of the section to be made can be read off on a circular disc divided into degrees, which can easily be applied to the instrument. Any other (much longer) knife can be substituted for the one in the instrument; the box in which the preparation is fixed can also be changed. The knife can be moistened by means of an " irrigator " with either alcohol or water, and the apparatus can be fastened to a wall so that the blade of the knife is horizontal. A microscopical preparation containing two sections of different thicknesses made with the above apparatus is enclosed for exhibition.

3642. Holle's Drawing Apparatus for the Microscope.

Cuno Rumann, Göttingen.

The construction of the apparatus has just been completed, and only one specimen has been made.

An account of its leading peculiarities will be found in the paper enclosed.

3643. Photograph of the Drawing Apparatus.

Cuno Rumann, Göttingen.

3644. Sectional View of Drawing Apparatus.

Cuno Rumann, Göttingen.

3645. Description of the apparatus of Prof. Grisebach, from the "Nachrichten von der Königl. Gesellschaft der Wissenschaften zu Göttingen." *Cuno Rumann, Göttingen.*

3646. Dr. Thoma's Stages (*see also* X. 21).
Rud. Jung, Heidelberg.

The three stages afford the means of making an exact microscopical examination of the tongue, the mesentery, and the interdigital membrane of the living frog, during the time that these parts are submitted to constant and determinate conditions by a continuous application of salt solutions of known concentration.

At the same time the apparatus allows continual infusions of different liquids, salt solutions, water, or colouring matters into the vena abdominalis mediana of the animal.

For directions for practical use see Virchow's Archives, vol. 65, page 36.

3647. Querschnitter, an Instrument for cutting under the Microscope. *Prof. Dr. V. Hensen, Kiel.*

The nature and use of the apparatus are given in the accompanying treatise. The instrument only differs from that described in having the curved piece (Bügel) turned forwards.

3648. Microtome, with steel disc, water-trough, wedge-shaped knife, four moulds. *Prof. K. Möbius, Kiel.*

3649. Two Microtomes, with steel disc and three moulds.
Prof. K. Möbius, Kiel.

A written explanation accompanies the objects exhibited.

3650. Five Moist Chambers, for microscopical research (after the designs of Recklinghausen, Ludwig, Geissler, de Bary, and Klebs). *Ch. F. Geissler & Son, Berlin.*

3651. Fritsch's Sliding Microtome.
Prof. G. Fritsch, Berlin.

The microtome, of which (on account of some recent alterations) an incomplete account is sent, has on its left a movable box for the reception of the object, on the right a slide (Schieber) with eccentric disc and screw as a holder for the knife. Other knives will be found in the lid for use, according to the degree of resistance offered by the object.

The object to be cut must be so placed in the metal box that the part to be cut projects over the upper rim. The preparation is imbedded in a suitable mass, or is frozen in a mixture fit for cutting (*e.g.* Rutherford's). In the brown lacquered box are plates of spermaceti, and mixtures of the latter with cocoa-butter, suitably selected. Some elder pith is imbedded as a specimen.

After an advantageous position, as regards the object, has been given to the knife, and the box containing the embedded object has been fixed by means of the screws of the large movable box, so that it can be cut by a gentle elevation of the movable box, the screws of the disc and knife are sharply drawn across. Should the position of the object be too low, one of the metal plates furnished with the apparatus is laid under the box, and the screw of the movable box again turned up, but not too tight, in order to prevent the strain and pressure on the side of the box becoming too great. The work of preparing is automatic, so that when a clear section surface is obtained, the movable box, by means of the vernier attached, can be raised a definite fraction in height, and the object in it; the knife screwed up on the slide is guided by means of the horizontal slot, whereby the uppermost part is taken off as a thin section. After drawing back the knife to the other end of the slot (turned from the operator), and a fresh raising of the box, a second section is obtained in a similar manner, and so on until the object is converted into thin sections. With objects difficult to cut it is necessary to moisten the blade during the cutting of the section with weak spirit contained in a wash bottle, one tube from which overhangs the blade, whilst the other is kept in the mouth for blowing. If the objects resist very much, so that the blade tends to give, then the safety of the section will be secured by laying the curved piece of metal from the mahogany box under the larger screw of the eccentric disc, and a corresponding tightening of the adjusting screw placed over the free end of the knife. The movable box can (for the purpose of keeping the left hand for guiding) be easily fixed by means of a clamping screw through the slot.

Some sample sections are contained in the mahogany box.

3651a. Microscopic Section Cutting Machine.
G. Moritz Leyser, Leipzig University.

3652. Counting Micrometer, for enumerating microscopical forms. To this is added a figure under glass, representing the micrometer magnified eight times.
Prof. H. Welcker, Halle an der Saale.

3653. Sliding Tray, carrying microscope lamp and Hartnack microscope, for demonstrating objects to a class.
W. R. M'Nab, M.D.

This tray runs on two rollers partly covered with india-rubber, thus destroying vibration, and permitting the tray to be used on an ordinary table.

3654. Mica-plates for preserving botanical and anatomical preparations. (*See* Mineralogy.) *Max. Raphael, Breslau.*

Mica-plates are conveniently employed for preserving hygroscopic anatomical preparations, such as of foliaceous mosses ("Laubmoosen"), &c., For this purpose, the mica is split halfway through, and the preparation placed, in a moist condition, between the plates, which close of their own account owing to the elastic nature of the mica.

Should the preparations be required for examination, the plates have only to be dipped for a second or two into water; they may thus serve for years for repeated microscopic examination. It is obvious that covering plates of mica may be used for all botanical microsopic purposes.

3654a. New adjusting and self-centering Shadbolt's Turn-table for making microscopic cells.
Harvey, Reynolds, and Co.

3655. Knife for cutting microscopic sections, by Dr. Gower, with divided adjusting screw. *T. Hawksley.*

3656. Knife, with three blades, for cutting microscopic sections by Dr. Madox. *T. Hawksley.*

3656a. Dr. Klein's Section Knife. *T. Hawksley.*

3657. Moist Chamber. *T. Hawksley.*

3658. Series of Glass Canulæ, and **Nozzles. Dissecting Instruments, Forceps, Scissors, Hooks, &c.** *T. Hawksley.*

3662. Preparations of normal anatomy of the human body, injected and varnished, in 1809, by Prochaska.

The microscope and preparations were given by the author to the first Baron Larrey, with the description in Latin that is affixed to the instrument. *Baron Larrey, Paris.*

3662a. Microscopic Section Cutting Machine, with Freezing Cell. *Harvey, Reynolds, and Co.*

3662b. Williams' Freezing Microtome. *J. Swift.*

3663. Microscopical Double Knife, constructed by A. Stelzig, surgical instrument maker in Prague. With flexible curved blades. Compared with knives of older shapes, the parallelism of the edges is to a much greater extent preserved in this form.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Prof. Edwin Klebs).

3664. Valvulotome. An instrument for making incisions in the valves of the heart, being a straight catheter, at whose front extremity, which is rounded, a small blade is attached, which by means of the screw inside the instrument can be opened, so that the free rounded end will project more or less. The edge of the knife is turned towards the catheter. After the introduction of the instrument into the jugular vein, or the carotid artery, the right or left ventricle of the heart can be easily reached. The blade having been protruded, the chordæ tendineæ of the heart are grasped and cut off by pulling the knife backwards into the catheter. Artificial disorders of the heart so produced have been observed for more than a year, and the circulation studied on cymographical curves.

(Prague Weekly Journal, '76. No. 2.)

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Prof. Edwin Klebs).

3665. Microscopical Warm Stage. The constant equality of the temperature is obtained by the increased bulk of the thick copperplate. The object is placed in the recess, and the centre aperture is closed by a glass disc. A broad, thick copper ring with central aperture for the object is placed on the upper surface of the disc, thus closing the aperture. The lateral movement of the microscope with the coppering is effected by a plate at the bottom of the apparatus on which the microscope is fixed. The same can be shifted in two directions, at right angles to one another by means of micrometer-screws. Four side-apertures admit the introduction of thermometers or liquids for keeping the chamber moist, or for the infusion of gas. A small gas-flame, which imparts heat to the adjoining piece, serves as a heat conductor.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Prof. Edwin Klebs).

3668. Microtome. A circular knife is set revolving by a turning-lathe. The preparations, which are embedded in a metal case, are moved forward by a micrometer screw, and passed across the edge of the rotating knife by a contrivance similar to that in a dividing engine.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Prof. Edwin Klebs).

3668a. Holman's Syphon Slide, invented to keep objects alive while under the microscope by a flow of cold water.

D. S. Holman, Philadelphia.

3668b. Holman's Life Slide.

D. S. Holman, Philadelphia.

By the cross groove causing live objects, such as vinegar eels, &c., to take up their position in it, they are enabled to be more readily examined.

3668c. Holman's Current Slide.

D. S. Holman, Philadelphia.

3668a. Fifteen Frames, containing photographs of **Microscopical Sections.** *Richard Daintree.*

II.—OPHTHALMOLOGICAL APPARATUS.

a. OPHTHALMOMETERS.

3692. Ophthalmometer, according to the directions of Professor Helmholtz.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

3693. Mirror Apparatus for the above, for measuring the radius of curvature of the different meridians, with balancing weight.

Aug. Becker (Dr. Meyerstein's Astronomical and Physical Workshops), Göttingen.

The mirror apparatus is fixed into the opening of the index disc, which is placed at the further end of the ophthalmometer. The instrument must, when put into use, be so placed upon a stand that the long rods of the mirror apparatus clear the disc of the stand, when it is rotated. A weight, passing over the telescope, balances the instrument.

3686. Coccius' Double-refracting Ophthalmometer.
E. Stöhrer, Leipzig.

Design of Apparatus.—To measure the principal curved surfaces by means of two movable sources of lights and Iceland spar with doubly refracting prism of Iceland spar whose angle of dispersion is about 3 mm.

Practical Application.—The cornea, on which three points of light (the distance of the images of the respective lights being three millimeters) or four points of light (the distance of the images from the respective sources of light thrown on the cornea being 1½ mm.) can be shown. In the last case the distance of the lights from each other is the half of the distance which three or four points of light show. When the position of the lamps is vertical, the Iceland spar must be turned round.

b. OPTOMETERS.

3710a. New Optometer, with double refracting lens of calcspar, give double readings, and greater precision in determining the distance of sight. *Prof. Carl Wenzel Zenger, Prague.*

3714a. Perrin and Mascart's Optometer.
M. Roulot, Paris.

3713a. Perrin and Mascart's Optometer (small pattern).
M. Roulot, Paris.

3713. Dr. Badal's Optometer. *M. Roulot, Paris.*

3697. Graefe's Binocular Optometer.
Dr. Weber, Darmstadt.

3710a. Optometer, for determining the condition, degree of refraction, and acuteness of vision.
William Laidlaw Purves, M.D.

The optometer consists of a disc of convex spherical, a disc of concave spherical, a disc of convex cylindrical, and a disc of concave cylindrical lenses. These move upon a central axis, so that any of the four discs can be superimposed upon another, and thus any combinations made which the particular lenses used can arrive at. The cylindrical lenses, having their axes all placed in the same direction, and at any one meridian of the instrument, the different powers are speedily brought before the eye, so as to act on the desired meridian of the eye, and on it only. (*Vide* "British Medical Journal" for January 1875.)

3710b. Boxwood Scale, on which the combinations are calculated: belongs to the optometer last described.
William Laidlaw Purves, M.D.

3710d. Instrument for the determination of the exact position of the **chief Meridians** of the **Eye.** *William Laidlaw Purves, M.D.*

This instrument consists of three round apertures, one in the centre, and two at equal distances from the periphery in the same meridian, bored in a screen. When these, placed against a strong light, give major axes of diffusion circles, the disc is revolved till all the major axes are on the same line. This lens has an indicator attached, which points to the degree on a graduated circle in which the disc revolves. (*Vide* Graefe's Archiv, 1873.)

3710e. Test Card for determining the **Acuteness of Vision** in any **Meridian.** *William Laidlaw Purves, M.D.*

This is a modification of the usual astigmatic test cards. By working the disc, and so bringing varied numbers of lines into any desired meridian, the acuteness of vision at that meridian is determined by the ability of the observer to count the number so placed.

3710c. Modified Stokes's Lens, for determining the degree and condition of refraction and acuteness of vision of any meridian of the eye, or of simple or combined lenses of less power than one-fifth. *William Laidlaw Purves, M.D.*

This is a further modification of Snellen's modification of Stokes's lens. In this modification the power of the lenses are increased from one-tenth to one-fifth. The constant axis is obtained by means of a screw and wheels, instead of by springs, and, in addition to former modifications, the exact position of the axis of the whole lens is obtained by moving the whole lens in a graduated circle. As each cylindrical lens acts only in one meridian, and that meridian is determined by the position in which the lens is placed, any number of meridians may be determined successively. The power required in any meridian is calculated in the usual way. (*Vide* Donders' Accommodation and Refraction of the Eye.) By using a modification of Scheiner's experiment, and other methods, the power of single or combined lenses may be determined. (*Vide* Graefe's Archiv, 1873.)

808. Stokes's Lens, modified by Dr. Snellen. In one and the same mounting are set two plano-cylindrical lenses (+12, −12) capable of rotation in opposite directions. When their axes are parallel, their refraction becomes annulled; when they are at right angles, they become added; in intermediate positions they give a graduated series of cylindrical refractions. The axis is fixed for the same reasons as above. *M. Crétès, Paris.*

3669a. Trial Box and collection of metrical glasses, for ophthalmology. *A. Nachet, Paris.*

3717. Set of Lenses for Testing the Sight.
W. Campbell & Co.'s successor, J. Wohlers, Hamburg.

3715. Box of Lenses, containing 120 spherical, 36 cylindrical, 10 prismatic, and two trial eyepieces. *M. Roulot, Paris.*

3715a. Box of Lenses, 120 spherical and trial eyepiece. *M. Roulot, Paris.*

3715b. Box of Lenses, 36 cylindrical and eyepiece.
M. Roulot, Paris.

3715c. Box of Lenses, from 2° to 20°, square, cylindrical.
M. Roulot, Paris.

c. PERIMETERS.

3714b. Dr. Badal's Perimeter. *M. Roulot, Paris.*

3680a. Dr. Forster's Perimeter. *R. Sitte, Breslau.*

This apparatus is used for determining the external limit and the colour limit of the defects of the field of vision. The position of the displaceable objects is read off by meridians and parallels.

A more detailed description will be found in Zchender's Klinischen Monatschriften für Augenheilkunde, 1869, p. 411.

3711. R. Brudenell Carter's Perimeter for ascertaining the boundary of the field of vision and the area of the blind spot. *T. Hawksley.*

d. PHOTOMETERS.

3695. Graefe's "Leuchtscheibe" (illuminating disc); from the property of the late Professor von Graefe.
Dr. Weber, Darmstadt.

3680. Dr. Förster's "Lichtsinnmesser."
R. Sitte, Breslau.

A source of light of constant intensity, but whose size can be varied, illuminates the object, which may be either black bands or large letters on a white ground. The source of light is behind a sheet of white paper, and shines only through it, the paper being illuminated on the other side by a standard candle burning at almost the same height. The size of the source of light depends on an adjustable diaphragm, whose centre always remains at the same point. The diagonal of the square aperture of the diaphragm is measured by a scale which moves with the plates of the diaphragm. The size of the illuminated surface $= \frac{d^2}{2}$, if half a square millimeter be taken as the unit. By means of this apparatus all quantities of light, from 1 to 2,500 units, can be estimated.

See Zehender's Klinische Monatsblätter fur Augenheilkunde, 1871, p. 387.

3720. Weber's Photometer and Chromometer.
Dr. Weber, Darmstadt.

3721. Weber's Chromoptometrical Apparatus.
Dr. Weber, Darmstadt.

The examination of the sense of colour with this apparatus rests upon the production of simultaneous contrasts, for which purpose a gray ring is placed upon the primary colour and both are covered with transparent paper. For the determination of the numerical size of the perception of colour, use is made of a gray disc which can be divided into sections, by means of which it can be determined in what relation the primary colour stands to the gray surface, in order to place upon it likewise the complementary colour. For determining the limit of the field of perception of colour, use is made of a number of concentric gray rings, for which the middle point of the prime-coloured surface serves as a centre which is fixed upon by the eye under examination.

e. TONOMETERS.

3675. Graefe's Tonometer (Augendruckmesser).
Dr. Weber, Darmstadt.

Graefe's tonometer has only an historical value, since it was the first apparatus with which he endeavoured to measure the tension of the eye-ball tegument; it could not, however, be introduced into practice on account of many inconveniences.

3676. Weber's Tonometer. *Dr. Weber, Darmstadt.*

3674. Tonometer, for Measuring the Tension and Convexity of the Eye-ball.
Geneva Association for the Construction of Scientific Instruments.

This apparatus is specially used for glaucoma. It serves to produce a definite deformation of the eye, which may be variable at the operator's will, according to the most suitable circumstances for a special case.

The instrument is composed of a rod, of which the ivory-tipped end presses upon and deforms the eye, while the other end acts upon a dynamometric spring, the flexure of which, amplified by a catch and by the indicating needle, shows in grammes upon the dial the pressure exercised upon the rod, and, consequently, upon the eye.

An index marks the greatest oscillations of the principal needle.

f. PUPILLOMETERS.

3671. Pupillometer. *Emil Stöhrer, Leipzig.*

g. EXOPHTHALMOMETERS.

3682. Cohn's Exophthalmometer, three specimens.
Prof. Dr. H. Cohn, Breslau.

These instruments possess a certain amount of interest, as they are almost the first instruments which were made for measuring the prominence of the eye from the orbit. Dr. Cohn exhibited the first of the accompanying instruments, on Nov. 17th, 1865, before the Medical Society of Breslau, and at the same time gave it the name of Ophthalmoprostatometer; but later, in the year 1867, he changed the name to Exophthalmometer. The second instrument Dr. Cohn has not publicly demonstrated, as he altered the principle of measurement; nevertheless he determined to send the instrument, so that one can judge of the reasons which induced him to regard the external wall of the orbit which he had taken as his fixed point (and is still so taken by some) as not suitable for the purpose. The third exophthalmometer with which the exhibitor finally carried out his measurements, was laid before the Ophthalmic Congress, at Paris, on the 12th of August 1867. Its peculiarities and applications are described in the accompanying pamphlet.

3682a. Cohn's Exophthalmometer, with band.
Prof. H. Cohn, Breslau.

3682b. Cohn's Exophthalmometer, with small handles.
Prof. H. Cohn, Breslau.

h. OPHTHALMOMETERS.

3710f. Ophthalmoscope, for the determination of the refraction of the observed eye by the observer.
William Laidlaw Purves, M.D.

Behind the mirror are two discs containing numerous convex and concave lenses, which may be brought rapidly over the aperture of the mirror by means of a rack moved by the thumb of the hand which holds the ophthalmoscope. As the convex can be revolved over the concave lenses, or *vice versâ,* any combinations can be made which the number of the lenses employed will allow of.

3710g. Ophthalmoscope, for the determination of the refraction of the observed eye by the observer.
William Laidlaw Purves, M.D.

Behind the mirror two cylindrical lenses, $+\frac{1}{8}$ and $-\frac{1}{8}$, are revolved on the same method as in Stokes's lens, and thus the powers, which have been calculated and marked on the instrument, are brought into use instead of using a number of lenses as in the instrument before described.

3681. Cohn's Refracting Ophthalmoscope.
Prof. Dr. H. Cohn, Breslau.

In the year 1871 the exhibitor constructed this apparatus for examining as quickly as possible a number of scholar's eyes. In 1872 the instrument was described in the Klinischen Monatsbl. of Augenheilkunde, in the October number. Twenty-four glasses can be quickly pushed past behind one and the same mirror. As the disc which bears these glasses is centred above the mirror, the nose of the observer cannot come into contact with it. There is no necessity to shift three discs with glasses, as in Loring's Ophthalmoscope. If the mirror be placed in front of the eye to be examined, and the patient looks through the central hole at some letters in the distance placed on an inclined table desk (as Snellen's alphabet), the instrument can be used instead of a test lens, and thus the wearisome selection of the glasses is avoided; in the same way, by quickly turning the disc with the correction glasses, its refrangibility for an object can be removed.

3708. C. J. Oldham's First Ophthalmoscope, with one diaphragm at back of mirror to carry lenses. *T. Hawksley.*

3709. C. J. Oldham's Second Ophthalmoscope, with three diaphragms and 27 lenses. *T. Hawksley.*

3719. Metrical Ophthalmoscope, of Dr. de Wecker. In one zone are placed 20 convex glasses ascending gradually from 0·50 to 10 metrical dioptric. To obtain the concaves, a concave lens is interposed, more powerful than the maximum of the convex glasses ($10\frac{1}{2}$ dioptrics), and by turning the wheel a descending series of 0·50 to 10·50 concave dioptrics is obtained.
M. Crétès, Paris.

3714. Dr. Giraud Teulon's Binocular Ophthalmoscope. *M. Roulot, Paris.*

3706. R. Brudenell Carter's Demonstrating Ophthalmoscope, showing the fundus oculi magnified to 12 inches in diameter. *T. Hawksley.*

3707. Dr. Lionel Beale's Self-illuminating Demonstrating Ophthalmoscope. May be used in daylight. *T. Hawksley.*

3696. Weber's Synamphophthalmoscope. *Dr. Weber, Darmstadt.*

The apparatus serves for the simultaneous investigation of both eyes in the inverted image, and thus permits a comparison of the details of the background of the eye as to size, colour, &c. In using it a double source of light and a perforated reflector are required.

3707a. Prof. Laqueur's Instrument for measuring the Ophthalmoscopic Image. *Prof. Laqueur, Strasburg.*

3684. Apparatus for giving Instruction in the use of the Ophthalmoscope; also 18 water-colour drawings in a box, giving the typical aspects of the retina, choroides, and optic nerve in health and disease, from nature. *Dr. Magnus, Breslau.*

This apparatus presents, in a very instructive way, the various laws of refraction of the eye, by shifting the lens which is contained in it; the apparatus can be used for demonstration with the greatest facility. Besides these physical problems, the apparatus has 18 water-colour drawings, painted by the exhibitor from nature, and showing the principal features of the healthy and diseased retina, choroides, and optic nerve, for the purpose of affording the student the opportunity of investigating ophthalmoscopically the pathological changes occurring inside the eye.

3673. Hermann's Blemmatotrope, for representing Listing's law of the positions of the eye. *Prof. Dr. L. Hermann, Zürich.*

This apparatus can be arranged for vertical, horizontal, or oblique axes of rotation, by changing the position of the arcs which support the eye-balls. The same number that is marked by the arc on the edge of the fixed concave disc behind the eye-ball, must be crossed, on the equatorial ring of the eye, by the red (vertical) meridian. When the axis of rotation is vertical or horizontal, the blue (horizontal) meridian corresponds, during rotation, with the thin brass plate (visual plane); when the axis of rotation is oblique, the horizontal meridian and the visual plane will form an angle (the so-called Raddrehungs-Winkel).

3669c. Diplometer, by Dr. Landolt. *A. Nachet, Paris.*

3689. Actinallactor, an instrument for demonstrating the persistence of light impression on the eye. *Prof. Buys-Ballot, Utrecht.*

It consists of a black circular cardboard, that can be turned by a handle round an axle passing perpendicularly through its centre. Excentrically is adjusted a second axle, round which turns a rod containing four coloured wafers, or beads, or ignited pieces of German tinder, forming the same figures as are shown by the bead of Wheatstone's photometer. These figures can be changed by differently fitting the india-rubber band behind the black board. Made and invented by J. van Dreeven, Amanuensis of the Physical Cabinet of Utrecht University.

3685. Coccius' Polarising Ophthalmoscope.

E. Stöhrer, Leipzig.

Design of Apparatus.—To investigate the eye with perfectly polarised light, the images being either erect or inverted.

Practical Application.—To determine the defects of transparency on the iris, the cornea, and refracting media of the eye, with reference to the degree of nebulosity in the retina, to facilitate the estimation of the degree of atrophy of the optic nerve, and by removing all reflections to obtain a more distinct view of the fundus.

3710. Couper's Ophthalmoscope, with five discs and 45 lenses, two mirrors which are adjustable for right or left eye.

T. Hawksley.

3679. Micrometer, for measuring objects in the fundus oculi.

Prof. Laqueur, Strasburg.

This apparatus is used for measuring in the living eye the real size of the "papilla," the diameter of the blood vessels of the retina, the size of the macula lutea, the distance of the latter from the external edge of the blind spot, also the dimensions of any extravasations of the retina.

For the method of using the apparatus, see Centralblatt der med. Wiss. 1873, No. 59.

It can also be used for determining the condition of the refrangibility of the eye in ophthalmoscopic examination, by placing the toothed part of the stems in front of the lamp which serves as a source of light.

An account of the apparatus is published in the Proceedings of the Ophthalmological Society of Heidelberg for 1875.

3687. Coccius' Micrometer for the Eye.

E. Stöhrer, Leipzig.

Design of Apparatus.—To measure the transparent and sensitive parts without contact.

Practical Application.—To observe any object in the cornea, scars, opacities, cloudiness of the pupil in diseases, the degree of movement of the iris, or the widening of the pupils by the inspiration.

3669. Instruments for Extraction of Cataract.

Dr. Adolph Weber, Darmstadt.

3678. Rose's Schistoscope, for the physiology of colour.

F. Schmidt and Haensch, Berlin.

3691. Apparatus for demonstrating the **Reverse Position of the Image** on the retina of the observer's own eye. (Old.)

Prof. Dr. Dove, Berlin.

3705. Dr. Archer Warwick's Endoscope. *T. Hawksley.*

3688. School Apparatus for the demonstration of the refraction of light in the eye. *Physiological Institution, Prague.*

3690. Schematic Eye, on Dr. Kühne's principles. *Rud. Jung, Heidelberg.*

About ten times the natural size. The cornea and lens are, as far as their optical values are concerned, as near as possible, imitations of the natural eye. The box is filled with water, containing a trace of quinine, and can be thus used for demonstrating the passage of the ray in the natural eye under differing conditions. By removing the lens the conditions of the eye after a cataract operation are represented. The plane cylindrical vessel filled with water can be used for illustrating astigmatism.

3669b. Schematic Eye, by Dr. Landolt. *A. Nachet, Paris.*

3694. Specimens of Transparent Drawing, showing cases of **Optical Illusion,** described in Prof. Helmholtz's Physiologische Optik.

T. A. Snyders, Lecturer at the Royal Polytechnic School, Delft.

To be used in the projecting apparatus of M. Duboscq. The figures are drawn in Indian ink on sheets of unpolished glass, which are afterwards rendered translucid by a thin layer of varnish.

3712. Perrin's Artificial Eye Apparatus. *T. Hawksley.*

3716. Various kinds of Optical Glass. *Weslëin, Paris.*

3717a. Box with Specimen Spectacles for Oculists. *W. Campbell and Co.'s successor, J. Wohlers, Hamburg.*

3683. Several Pairs of Cohn's Mica Spectacles, manufactured by M. Raphael in Breslau. *Prof. Dr. H. Cohn, Breslau.*

In February 1868 the exhibitor examined the eyes of 1,283 metal workers and, in consequence of the enormous frequency of injuries to them, caused the first pair of mica spectacles to be made. They cannot splinter, and are extremely cheap. They are recommended for workmen who manipulate explosive materials. In the accompanying pamphlets is shown the gradual perfection to which these glasses have been brought by the manufacturers, Messrs. Max Raphael, Breslau, under Dr. Cohn's directions.

III.—WEIGHING AND MEASURING APPARATUS.

PROFESSOR A. CRUM BROWN'S PREPARATIONS AND APPARATUS.

3733. Skull with internal ear prepared for the measurement of the relative position of the planes in which the semicircular canals are situated.

Two saw-draughts are cut through the outer table of the skull, forming a large angle with one another. These saw-draughts pass through the mastoid part of the temporal bone, and are continued into the neighbouring parts of the skull; two pieces of steel plate are cut so as to fit into the saw-draughts, and the position in which they fit indicated by marks on the plates and on the mastoid bone. The greater part of the mastoid and the whole of the petrous portion are then sawn out, and the steel plates fixed to the portion of bone thus removed. This portion can now be replaced exactly *in situ* by placing the ends of the steel plates into the portions of the saw-draughts remaining on the skull. The remaining portion of bone is now plunged into a bath of fusible metal, and placed under the receiver of an air pump. On exhausting, bubbles of air escape from the cavities in the bone, and, on re-admitting air, these cavities are filled with fusible metal. By repeating this operation ten or twelve times in different positions, all the air can be pumped out and the cavities completely filled with fusible metal. The bone is now removed from the bath of fusible metal, and the adherent metal removed. It is then placed in melted paraffin, so as to cover the steel plates, and the greater part of the mastoid portion. When the paraffin has solidified, the whole is placed in a vessel containing dilute hydrochloric acid. This dissolves the unprotected part of the bone, leaving a cast of the cavities in fusible metal. From this the casts of the mastoid cells are carefully removed. To the external part of the mastoid is now soldered a brass pin fitting into a socket in the large goniometer. The cast can then be brought successively into positions in which each of the canals lies in a horizontal plane. In each of these positions the skull is replaced by means of the steel plates, and a glass plate fixed to the skull in a horizontal plane. These plates are therefore parallel respectively to the planes of the canals; and their relative position can be ascertained by means of the goniometer. *See* Proceedings of the Royal Society of Edinburgh, January 1874, and Journal of Anatomy and Physiology, viii. 327.

3734. Skull of Owl, prepared to show relative position of the semicircular canals of internal ear.

The spongy osseous tissue has been removed from the dense bones forming the canals, and these have been coloured so as to indicate the pairs of parallel canals.

3735. Skull of Crow, prepared to show relative position of the semicircular canals of internal ear.

3736. Skull of Heron, prepared to show relative position of the semicircular canals of internal ear.

3737. Cast, in plaster of Paris, of internal ears of the skate.

3738. Apparatus for measuring the relative **position** of the **planes** in which the **semicircular canals** of the **internal ear** are situated, with skull, illustrating its application.

The apparatus is simply a reflecting goniometer on a large scale. The telescope used with it is not sent, as it requires to be fixed at a considerable distance from the apparatus.

The mode of preparing the ear for observation is described above.

3739. Cast, in solder, **of human internal ear,** right side.

3722. Craniometer, by which measurements of crania may be taken rapidly and accurately. *Prof. Struthers.*

It is essentially a glass box, the panes accurately ruled and fitted into a carefully made brass frame. Sides 9 inches square; ends, bottom, and top, 9 inches by 7 inches. Bottom of strong plate glass. Top lifts out. Panes ruled both ways at distances of an inch. Middle division of each pane is halved by a median line, which is cross-marked at each $\frac{1}{4}$ inch. Skull placed so that middle line corresponds to middle line of panes. By looking through panes, and getting eye on corresponding lines of opposite pane, accurate measurements may be easily and rapidly read off of top, sides, front and back, or of interior of base. For outside of base, cranium is turned over and steadied. The cranium contained in the craniometer is a well-marked specimen of the scapho-cephalic form, with the usual early obliteration of the inter-parietal suture. The instrument was made for Professor Struthers by Mr. P. Stevenson, philosophical instrument maker, Edinburgh. An account of this craniometer was given by Professor Struthers in the Edinburgh Medical Journal, 1863.

3722a. Craniometer, an instrument for taking measurements of the human cranium. *Geo. Busk.*

The instrument is constructed on the principle of the common shoemakers' gauge, and consists of a straight stem about 12 inches long, having an arm jointed to it at one end, which can be erected so as to stand at a right angle, and a second arm which can be slid up and down the stem, and is also capable of being erected to a right angle, so as to stand exactly parallel with the former. The stem and arms are graduated on one side in inches and tenths, and on the other in centimeters and millimeters. The graduation of the stem, begins at the fixed arm, and that on the arms from the stem. In order to render the instrument capable of taking radial measurements, a conical peg can be slipped upon each of the arms, the points of which are inserted into each external auditory foramen. The radial distance from the centre of the foramen can thus be measured to any point on the periphery of the skull in the mesial plane, the distance being read off on the short arms.

3727. Dr. F. W. Spengel's Craniometer.
A. Wichmann, Hamburg.

An account of the fixing of the skull, as well as the use of the apparatus, is given in the accompanying "Correspondenz-Blatt der deutschen Gesellschaft für Antropologie, Ethnologie und Urgeschichte.

3728. Virchow's Portable Craniometer.
A. Wichmann, Hamburg.

3729. Virchow's Tactile Compasses (Æsthesiometer).
A. Wichmann, Hamburg.

3730. Virchow's Scale. *A. Wichmann, Hamburg.*

3731. Kephalograph or Craniometer, to determine the shape and dimensions of the human skull.
Dr. P. Harting, Professor at the University of Utrecht.

This instrument, which is intended to determine the shape and dimensions of the human skull, consists of three principal parts or distinct instruments.

The first (Fig. 1., Pamphlet) is intended to fit round the head, and to trace its principal circumference.

The second (Fig. 2) may be fitted lengthwise, crosswise, or in any other direction required.

The principal use of the third (Fig. 3) is to determine the profile of the face.

For further particulars, see the monograph "Le Kephalograph," by Professor Harting.

3723. Balance for Physiological and Clinical Purposes, on polished oak.

The Brandenburg Balance Manufactory, Messrs. Kuhtz & Co., Brandenburg on the Havel.

These balances and weights are being extensively used in all scientific schools, and especially by practising physicians. They are available and almost indispensable for the investigation of the disturbances of nutrition in childhood; for the estimation of the loss or gain of weight by the body during the course of lung disease, diabetes mellitus, acute diseases, &c.; for the study of the normal growth of the body; and for pathological and anatomical investigations in which weighings are required.

The balance carries 150 kilogrammes and turns with 0·25 grm. By means of the pointer attached to the beam and the ivory scale, a still smaller difference in weight can be detected.

3724. Set of Iron and Brass Weights, accurately adjusted.

The Brandenburg Balance Manufactory, Messrs. Kuhtz & Co., Brandenburg on the Havel.

2549. Drawings (4) of two apparatus for testing the **Products** of the **Perspiration** of **Animals;** the larger of this apparatus is destined for horses, cattle, swine, and sheep, &c.; the smaller serves for the same researches on poultry and rabbits, &c.

Prof. Dr. Ignaz Moser, Vienna.

3732. Manometer, with movable level of the mercury.

Physiological Institution, Prague.

The above is a quicksilver manometer, the legs of which communicate with a vessel containing mercury; the bottom can be lowered or raised by means of a screw. The manometer allows, among other things, a very quick measurement of the pressure of the saliva, during secretion.

3740. Dynamometer for **Paracentesis Thoracis,** by Dr. Douglas Powell. *T. Hawksley.*

3741. Dr. Douglas Powell's Instrument for **measuring Thoracic Resilience.** *T. Hawksley.*

3741a. Instrument for the **Identification** of **Persons.**

Joseph Bonomi.

The normal proportion of the human frame is that the measure of the distance from the extremity of one hand to the extremity of the other when the arms are extended should be the same as that from the top of the head to the sole of the foot, and any departure from this normal proportion furnishes a means of individual identification.

The purpose of the instrument is to obtain these two measurements simultaneously.

It consists of two laths of wood fixed at a certain angle against a wall. Down the centre of each lath is a groove in which slides an index to show the required measurements. The third index below is for the purpose of ascertaining with great nicety the law of growth in the dimensions of the external divisions of the human figure.

IV.—CHEMICAL APPARATUS USED IN PHYSIOLOGICAL RESEARCH.

3742. Closed Flask for Experiments in Abiogenesis, &c.

Prof. D. Huizinga, Director of the Physiological Laboratory of the University of Groningen.

The neck of the flask is surrounded by a glass cylinder closed below so that a circular groove is formed. When the liquid in the flask has been raised to boiling temperature, the flask is closed by the previously heated iron cylinder, the under surface of which, as well as the mouth of the flask, have been carefully ground so as to fit accurately. The circular grooves at the top and bottom of the cylinder are then filled with heated mercury. The steam now escapes through the axis of the cylinder. When ready for closing, after sufficient boiling, the lateral silver tube is heated by a pair of gas burners, and the bell-shaped iron cover is also heated and placed on the top of the cylinder so as to dip into the mercury of the upper groove. The flame under the flask is then removed. The air which now enters the flask must necessarily pass through the continually heated silver tube. If judged necessary, the inner width of this tube can be reduced by passing through it a platinum wire.

In experiments on abiogenesis a hatching apparatus is then applied to, but without touching, the flask, so that during the whole experiment the silver tube remains exposed to the flames of the burners.

The lateral iron bar with the movable weight serves for equilibrium, so as to secure a firm position for the whole on the mouth of the flask.

3743. Dialyser.

Prof. D. Huizinga, Director of the Physiological Laboratory of the University of Groningen.

A piece of parchment is glued on both sides of an ebony frame, and strips of the same material are glued about the edges, and thus is formed a perfectly tight bag. The whole is then exposed to diffused daylight, the superfluous bichromate removed, and the dialyser is ready for use. The glue used is a mixture of gelatine and bichromate of potash.

The dialyser can be tested thus :—

1. When the paper is dry and water poured in, no perceptible drops of moisture, even after long standing, ought to appear on the outer surface.
2. A fresh solution of hæmoglobine (diluted fresh blood) being poured in, and the dialyser placed in water, should the red hæmoglobine appear in the water the apparatus is defective.

For further particulars respecting this apparatus *see* "Archiv für Physiologie," Vol. xi. p. 392.

3744. Two Self-acting Filtering Glasses, for microscopical reagents. *Prof. Jessen, Eldena, in Pomerania.*

V.—THERMOMETRIC APPARATUS USED IN PHYSIOLOGICAL RESEARCH.

Thermometer, in the shape of a little frog; it contains balls of different densities and differently coloured, which sink in succession as the fluid within the instrument rises in temperature and consequently diminishes in density. It served, being tied to the arm, to determine the degrees of heat in fever.

The Accademia del Cimento.

The thermometer invented by Galileo underwent afterwards important improvements. Giov. Francesco Sagredo, a noble Venetian, and a very great friend of Galileo, wrote to him on the 9th of May 1613 as follows:—"I have succeeded in reducing the instrument, which you have invented for "measuring heat, into several very convenient and delicate shapes, inasmuch "as the difference between the temperature of two rooms can be seen up to "100 degrees, &c."

It was Sagredo, who, in 1615, first hermetically closed the thermometer.

Other improvements were effected by the Grand Duke Ferdinand II. The following is what Padre Urbano Daviso says about them in his book entitled "Pratiche Astronomiche." Having first of all described a thermometer similar to Galileo's, he proceeds—"But His Serene Highness, not being satisfied with "this invention, endeavoured to render it absolutely perfect. He constructed "a little glass phial, of about the size of a musket-ball, with a neck of about "the length of half a palmo, but so thin that it is barely possible to insert a "millet-seed into it. Being filled with well refined spirit, either coloured "or in a natural state, in sufficient quantity for it to reach up to the middle "of the tube, and then the mouth being closed with a seal of hermete, it will "show by means of the rising or falling of the liquid in the neck (which "must have points marked on it for that purpose) the degree of greater or "less heat or cold. And it has this advantage over the other instrument, "namely, that the latter could only show the state of the air, whilst this one "indicates, in addition to the temperature of the air, that of any liquid "in which the bulb shall have been immersed; hence it will be possible "to warm water, or a room, or a furnace to any degree, and to keep it "in that state, or increase it, just as one pleases. Thus it will be easy to "find out when a thing has been heated to the degree that was necessary for "cooking it properly, operations from which, it may be said, that the "chemical art has received its finishing touch. And in the same way it will "be possible with instruments of this kind to find out the state of heat or "cold of any place or province . . . . . And by this means it has been "discovered that the water of wells and springs, as also cellars, grottoes, "and other deep subterranean places, which in winter seem to our senses to "be warmer than in summer, are, in fact, of the same temperature at both "seasons. And we are, therefore, forced to say that the apparent difference "comes from the surrounding atmosphere which affects our senses, and not "from any change in the degree of heat or cold in the vaults."

As to the way of dividing them into degrees, the Diario dell' Accademia del Cimento says that the cinquantigrado "immersed in melting snow, "descended to 13½ degrees, although on some occasions the cold air at "Florence reduced it to 7°. And when exposed to the rays of the sun at "midsummer, in the open air, and free from any kind of reflection, it rose "to 43°, and at the same season, in the shade, to 34°." So that the difference between the cold of ice and the heat of the sun was divided into 30 degrees, and these were the points of comparison for the thermometers of those days.

With regard to meteorological observations, they were instituted in the year 1654, by the Grand Duke Ferdinand II. and continued by the Accademia del Cimento. They used to be taken at Florence at the Palazzo Pitti, at the Giardino Boboli, and at the Convento degli Angeli; and afterwards at Cutigliano, Vallombrosa, Bologna, Parma, Milan, Warsaw, Innsbruck, &c. Observations were usually made, at different hours of the day, of the state of the thermometers exposed to the north and to the south; the condition of the sky, the direction of the wind, the barometric pressure, and the moisture of the atmosphere. Now, if these observations taken so long ago, be compared to recent ones, it will be seen that, after due corrections have been made, or if observations be taken now with some of the best instruments of the Accademia del Cimento, the meteorological conditions of Tuscany have not changed.

It was with the thermometer No. 13 that the members of the Accademia del Cimento carried out their first experiments on radiant heat, which showed how both the heat of burning cinders and the cold of ice are reflected, according to the same law, by a concave mirror. Illustrations of these experiments are to be seen in the photograph of Galileo's Gallery, in the lunette on the right hand side of the Tribuna.

Several thermometers, similar to No. 14, were placed by the Grand Duke in his rooms, in order to secure an equable temperature in all of them.

As to thermometer No. 17, most important use was made of it for determining the temperatures of sick persons. The various degrees of heat were shown by the sinking of little balls of different colours in proportion as the temperature rose.

At the present day we have returned to the cylindrical shape of thermemeter bulb, already used by the Accademia del Cimento.

3745. Clinical Thermometers, made upon Dr. Phillip's principle. *Francis Pastorelli.*

The ball and part of the stem are filled with mercury; above the main column, separated by an air speck, is a small mercurial index; when heat is applied to the ball the column and index are driven forward; on cooling the main column only recedes, the index remains, the upper end of which indicates or measures the amount of heat applied. Above the air speck the space is a vacuum.

3745a. Dr. Clifford Allbutt's Clinical Thermometers; Fahr. and Cent. scales; various patterns.

Harvey, Reynolds, & Co.

The general introduction of the thermometer for ascertaining the temperature of the body in disease indicates one of the chief advances in the methods of diagnosis.

Dr. Aitken used thermometers 10 inches long, and the instrument was hardly met with beyond the wards of a few hospitals. In 1867, Dr. Clifford Allbutt requested Messrs. Harvey, Reynolds, and Co. to make instruments with a chamber anterior to the bulb, reducing the length of the tube from

10 inches to 6 inches, then to 4 inches, and to 3 inches. From that time the use of the clinical thermometer has rapidly extended, until now it is found in the pocket of almost every medical practitioner.

3745b. Clinical Chart Forms for temperature, &c.
Harvey, Reynolds, & Co.

Quarto size for hospitals; octavo size for medical practitioners and their patients. Designed by Edward Casey, M.D., Windsor.

3745c. Registering Clinical Thermometers for the Pocket. *Harvey, Reynolds, & Co.*

The clinical thermometer, as introduced by Dr. Aitken, was made of the length of 10 inches. It was seldom used beyond the walls of a hospital, from its want of portability. In the year 1867, Dr. Clifford Allbutt, of Leeds, requested the exhibitors to make for him a thermometer of the length of 6 inches, the reduction in the length of the stem being compensated by making a small chamber in the bulb. This served for the retreat of the mercury at temperatures below 90° Fahr.

Instruments of the length of 4 inches and 3 inches were subsequently made, and the result of this portability has been the universal adoption of the clinical thermometer in medical practice in Great Britain. Beyond this, physicians often direct patients to be guided by its indications as to when to send for medical advice.

3746. Standard Thermometer, for physiological purposes, 0°–50°, divided into $\frac{1}{10}$° (Virchow).
Ch. F. Geissler & Son, Berlin.

3747. Standard Thermometer, for physiological purposes, 30°–45° (Heidenhain). *Ch. F. Geissler & Son, Berlin.*

3748. Two Pocket Maximum Thermometers, for the use of physicians, in a case and ebonite sheath.
Ch. F. Geissler & Son, Berlin.

3749. Geissler's Standard Thermometer, for determining the temperature of the skin, divided into $\frac{1}{10}$°.
Ch. F. Geissler & Son, Berlin.

3750. Geissler's Standard Thermometer, for determining the temperature of the ear. *Ch. F. Geissler & Son, Berlin.*

3751. Rosenthal's Electrical Thermometer, for determining animal heat. Constructed by Dr. A. Lessing, of Nuremberg. *Prof. Rosenthal, Erlangen.*

The electro-thermometer consists of a bundle of iron and German silver wires, which is contained in an elastic catheter, and can be easily introduced into any cavity of the body. It serves for the measurement of the temperature of the body in different places, and especially for lecture demonstrations. The resistance of the exhibited example = 0·25 Siemens' units. For introduction into the heart, *e.g.*, by the jugular vein, a smaller sized instrument must be used.

3752. Circulation Thermometers, in pairs, 12″ long, divided from 35° to 45° centigrade. May be read to $\frac{1}{40}$ of a degree. *T. Hawksley.*

3752a. Dupré's Thermometer, with spiral bulb and silver reflector, for ascertaining the temperature of the surface of the body. *T. Hawksley.*

3752b. Pair of Clinical Thermometers. *E. Cetti & Co.*

3752c. Three Clinical Thermometers, in cases. *E. Cetti & Co.*

1037. Two Thermometers, on the plan of Virchow, for physiological investigation. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

1042. Two Thermometers, for medical purposes, on the plan of Traube, divided in tenths from +25 to +45° C. *Will. Haak, Neuhaus am Rennweg, Thüringen.*

VI.—APPARATUS FOR INVESTIGATING THE FUNCTIONS OF CIRCULATION AND RESPIRATION.

3753. Hermann's Heart Pump. *Prof. Dr. L. Hermann, Zürich.*

This apparatus, exhibiting the action of the auricle, may be applied in connexion with Weber's model of the circulation of the blood. The auricle (the narrow chamber of the pump), without entrance valve, works in such a manner that the heart receives blood from the veins both during the systole and the diastole of the ventricle (the wide chamber). When the play of the auricle is prevented, by shutting off its piston from the lever, the heart receives blood only during the diastole of the ventricle.

3957a. Prof. Rutherford's Model of the **Circulation** for explaining the **Blood Pressure** and the **Pulse.** *Prof. Rutherford.*

Model of the circulation for explaining the blood pressure and the pulse. The tubes are filled with water. The heart is represented by an elastic pump. The apparatus is fully described in the Journal of Anatomy and Physiology, Vol. VI., p. 249.

3754. Apparatus for Artificial Respiration.

Prof. Stricker, for the Institute for General and Experimental Pathology, Vienna.

The apparatus consists of clockwork set in motion by two steel springs, each five centimètres wide, and 598 centimètres long. The clock moves bellows, through which an animal, narcotized for the experiment, can receive sufficient air to maintain circulation.

To give the clockwork (made by Siegfr. Marcus, of Vienna) a uniform movement, Professor Stricker has constructed a regulator the principle of which is that with increasing velocity in the rotation of a balance wheel, two rods are thrust from the plane of the wheel, which act against a brush and so diminish the velocity. As the position of the brush can be regulated, the checking of the velocity can be commenced at any time within certain limits.

The clockwork can be made to work the bellows from 12 to 160 times per minute.

3755. Lowne's Patent Portable Spirometer.

R. M. Lowne.

The measurement of the vital capacity is obtained by measuring the velocity of the expired current during the time of expiration, and the instrument is arranged so as to reduce the velocity of the current to cubic measure. The indications of the instrument are shown by means of hands revolving on a dial which denote the number of cubic inches expired.

3755a. Improved **Portable Spirometer.** *E. Cetti & Co.*

3755b. Hæmotachometer of Vierordt (1857).

Prof. Vierordt, Tübingen.

The stand to be used with the instrument is omitted.

3756. Pump for Transfusion of the Blood. Invented by Dr. Valentin.

Geneva Association for the Construction of Scientific Instruments.

This instrument is provided with a glass cylinder, thus rendering visible the presence of air in the pump. The piston also is made of a single piece of glass, which ensures the greatest possible cleanliness.

3756a. Blood Transfusor. *Collin & Co., Paris.*

3756b. Spiroscope. *Collin & Co., Paris.*

3756c. Aspirator of Liquids. *Collin & Co., Paris.*

3756d. Apparatus for delicate Injections.

Collin & Co., Paris.

3756f. Hematimeter, apparatus intended to determine the number of globules in the blood, by Dr. Hayem and A. Nachet.

A. Nachet, Paris.

3757. Sphygmograph of Vierordt (1853).

Prof. Vierordt, Tübingen.

The pad for fixing to the arm with the weights for equilibrating the instrument are omitted.

3758. Photo-sphygmograph, with magnesium lamp, condenser, and plaster cast.

Dr. S. Th. Stein, Frankfort on the Maine.

This apparatus is used for photographing the human pulse. See Vogel's "Photogr. Mittheilungen," September and October 1875. Specimens of the photographs, a normal and fever pulse tracing, accompany the instrument.

3759. Sphygmodynamometer, an apparatus for estimating the blood pressure in the radial artery of man.

Dr. C. Friedländer, Strassburg.

The apparatus is made for determining the variations of the blood pressure in the radial artery in man; *e.g.*, the diurnal variations, the changes which the blood pressure suffers under the influence of poisons and various physiological and pathological conditions. Thus the apparatus is actually intended for purposes different from those of the sphygmographs which have been hitherto described, but it can also be used as a sphygmograph. A description of it will shortly be published in a physiological journal.

3760. New Sphygmograph (Sommerbrodt's).

Dr. Sommerbrodt, Breslau.

This sphygmograph transfers the movements of the wall of the blood vessel to a point moving up and down vertically by means of a one-armed weighted lever, and has a contrivance for fixing, which excludes, especially in researches on the radial artery, any vibration of the apparatus.

The performance of this apparatus in relation to the already known characteristics of the pulse traces surpasses in a striking way that of Marey's sphygmograph, which has hitherto been universally used, and which depends on the action of a spring. Besides, it has been possible, with the help of this apparatus, to make a series of new observations on the pulse curves given by the radial artery, and to discover some completely new features which it presents. The details of these observations are given in a paper published in March of the present year, which bears the following title:—"Ein neuer Sphygmograph und neue Beobachtungen an den Pulscurven der Radialarterie von Dr. Julius Sommerbrodt. Privatdocent, Breslau. A. Gosohorsky's Verlagsbuchhandlung (Adolf Kiepert).

3761. Riegel's Double Stethograph. *Weber, Würzburg.*

3762. Sphygmograph. *Weber, Würzburg.*

628. Portable Pneumatic Apparatus.

Prof. Dr. Weldunburg, Berlin.

This apparatus serves for condensing and rarefying air for medico-therapeutical and physiological purposes. It is possible by its means—

1. To inspire during its use compressed air whose degree of compression remains constant, but the compression of which can be varied to any extent by means of a known weight lying on it.
2. To exhale into rarefied air whose rarefaction is known and can be varied by means of the superimposed weight.
3. To inspire rarefied air.

These three methods of action not only produce a certain mechanical effect on the organs of respiration, but also affect the heart and the circulation. The apparatus is therefore adapted for studying the physiological action of compressed and rarefied air on the circulation and respiration.

Its principal applications, however, are to medico-therapeutical objects, for which its mechanical action renders it applicable; as, 1, the inhalation of compressed air; 2, exhalation into rarefied air; and, 3, inhalation of rarefied air. As a remedy it is suitable for a series of lung and heart diseases; as, for example, the exhalation into a rarefied atmosphere has been ascertained to be beneficial in many cases of emphysema of the lungs and asthma. The inhalation of compressed air in the treatment of pleuritis, bronchitis, phthisis, &c.

3763. Pneumatometer. *Prof. Dr. Weldunburg, Berlin.*

This instrument consists of a manometer, one limb of which is connected by means of a tube with a mask for the face. It is used for measuring the force of inspiration and the force of expiration in healthy and diseased individuals. In persons who suffer from diseases of the organs of respiration, the instrument not only gives the measure of the strength of inhalation and exhalation as such, but especially records the relative proportion in which each function is modified, so that in certain diseases the force of inhalation is principally or entirely affected; in others, the force of exhalation; and in others finally, both are affected. In this way the pneumatometer serves as a new physical expedient for the diagnosis of disease.

3764. Kymographion, for the registration of the pressure of the blood and of the respiratory movements on a blackened surface of 250 centimetres long and 23 centimetres high, which may be changed for another within half a minute.

Physiological Institution, Prague.

Accessory apparatus are used for the blackening and for fixing on the black. Two quicksilver manometers, one spring manometer, and a drum recorder. Several may be put into action, either singly or together. An electro-magnetic signal apparatus marks every single and every fifth second. Two other similar signal apparatus serve in connexion with two differently constructed electric double keys for marking the beginning or end of the electric shocks, or other effects. The rapidity of the movement of the blackened paper is variable within wide limits.

3765. Apparatus for Artificial Inspiration and Expiration. *Physiological Institution, Prague.*

Two pumps working synchronously, one of which is devoted to inspiration, the other to expiration. The number and depth of the respiratory acts are variable within wide limits. The apparatus allows also the employment of mixtures of gases and the preservation of the air expired without loss.

3766. Portable Injection Apparatus, with constant pressure, for artificially filling the blood and lymph vessels.

Physiological Institution, Prague.

By means of this apparatus every pressure between 2 and 300 mm. of mercury can be produced, and it remains unaltered during the whole continuance of the injection. The apparatus may be used for the simultaneous injection of two groups of vessels.

3767. Scheme of the Circulation.

Physiological Institution, Prague.

The apparatus consists of two glass cylinders, communicating by a horizontal tube, one representing the arterial, the other the venous, system. In the horizontal tube there is, in imitation of the capillary system, a sponge, in which the resistance to the current may be diminished or increased at will by means of a screw. A small pump brings the fluid with the desired force, or in the desired quantity, from the venous into the arterial system.

3768. Gas Sphygmoscope, by Sigismund Mayer. *Physiological Institution, Prague.*

The apparatus consists of a small drum or capsule placed on the skin above a beating artery, through which common coal gas is allowed to flow towards a burner. Each pulsation causes a contraction of the flame, and shows, among other things, very plainly the dicrotism of the pulse.

3769. Apparatus for the Registration of the Respiratory Movements. *Physiological Institution, Prague.*

The above consists of an air-tight case containing a living animal, which breathes through a tube fastened in the trachea. This tube communicates with the atmosphere through the side of the chest. The air enclosed in the chest is moved in oscillations of pressure by the breathing of the animal, and these oscillations are registered on the kymographion.

The apparatus allows at the same time the registration of the pressure of the blood, the section of the nervi vagi, the irritation of any desired nerves, and the injection into the jugular vein, without opening the case.

3770. Apparatus for **Registering** the **Respiratory Movements.** *Physiological Institution, Prague.*

In this apparatus the animal inhales from a large air-tight closed receiver, which communicates with the trachea by a tube. The changes in the pressure of the air in the receiver, thus produced, are shown on the kymographion. The air in the receiver is frequently renewed.

3771. Apparatus for the **Demonstration** of the mechanical influence of the **Action of Breathing** on the circulation of the blood. *Physiological Institution, Prague.*

3772. Sphygmometer by Dr. Handfield Jones. *T. Hawksley.*

3773. Sphygmometer by Dr. Sibson. *T. Hawksley.*

3773a. Original Double Stethoscope, invented by Arthur Leared, M.D. *Dr. Burdon Sanderson, F.R.S.*

3773b. Double Stethometer, invented by Arthur Leared, M.D. *Dr. Burdon Sanderson, F.R.S.*

3774. Stethometer by Dr. A. Ransome. *T. Hawkesley.*

3775. Dr. A. Ransome's Stethograph for delineating the movements of the ribs during respiration. *T. Hawksley.*

3776. Dr. Burdon Sanderson's Kymograph, arranged for taking continuous ink tracing of the movements of the arteries. *T. Hawksley.*

3777. Dr. Burdon Sanderson's Kymograph with smoked cylinder for spiral traces. *T. Hawksley.*

3778. Dr. Oliver's Kymograph, with Sanderson's Cardio graph and Marey's Tambour, arranged for spiral traces, for use a the bed side. *T. Hawksley*

3779. Five hundred yards of Paper for continuous traces. *T. Hawksley.*

3780. Dr. Burdon Sanderson's Cardiograph for recording the movements of the heart. *T. Hawksley.*

3781. Dr. Burdon Sanderson's Stetho-Cardiograph for recording the movements of the chest and the heart. *T. Hawksley.*

3782. Marey's Sphygmograph, with improvements by Drs. Sanderson, Sibson, and Handfield Jones, for recording the motion of the pulse. *T. Hawksley.*

3783. Dr. F. Sibson's Cardiograph for right and left ventricles and apex of heart. *T. Hawksley.*

3784. Marey's adjusting Pneumatic Tambour. *T. Hawksley.*

3785. Electro Marker. *T. Hawksley.*

3786. Electro Magnetic Marker. *T. Hawksley*

3787. Voit's Apparatus for investigating the gases given off in the respiration of small animals, exhibited in the Physiological Institute of Munich. *C. Stollnreuther, Munich.*

3788. Box containing **Apparatus** for the direct **Transfusion** of the **Blood**:—

1. Regulating canal formed by two tubes.
2. Three canals terminating in olive wood, shaped like a clarionet reed to insert in the arteries of animals.
3. Hollow and lancet.
4. Three canals of steel, reed-shaped, to fix in the regulating canal.
5. Two pincers for compression.
6. India-rubber tube for joining the regulating canals to the arterial canal.

More detailed explanations as to the mode of setting up the apparatus, and the different positions of the internal tube as to the regulating canal, will be found in the description of the apparatus, two copies of which, with sketches and plans, are appended.

Dr. Giuseppe Albini, Professor of Physiology in the Royal University of Naples.

4557. Drawings of Scientific Instruments in the University of Turin. *Director, Dr. Angelo Mossi.*

1. Physiological apparatus, for measuring the movements of the blood-vessels:—

A. Pletismograph, and apparatus for producing artificial circulation in organs separated from the body.

B. Pletismograph, to note the movements of the blood-vessels in man. (See two printed descriptions attached.)

3788a. Copy of "Ueber einen neuen Respirations Apparat." *Dr. Max Pettenkofer, Munich.*

3788b. Mosso's Plethysmograph, modified by Kronecker, and photograph of the same. *Prof. Gerald Yeo.*

3788c. Kronecker's Improved Manometer for frog's heart. *Prof. Gerald Yeo.*

VII.—ELECTRICAL APPARATUS USED IN PHYSIOLOGY.

3789. Hermann's Universal Commutator, with adjustable contact-springs. *Prof. Dr. L. Hermann, Zürich.*

This apparatus may be turned by hand or by water power, and admits of many physical and physiological applications, *e.g.*: 1. Closing a simple electrical circuit ("interruptor"). 2. Change of direction in a simple electrical current ("inversor"). 3. The same in two circuits, for instance, in determining resistance in a polarisable conductor, by Wheatstone's method, under currents of changing direction. 4. Choice between opening or closing induction currents (Dove's "Disjunctor"). 5. Determination of the polarisation residuum in a conductor after shutting the current (like Siemens's "Commutator"). 6. Comparison of two residua of polarisation, by connecting the two conductors with the galvanometer, one opposite to the other. 7. Many physiological rheotomic inquiries.

3790. Hermann's Non-Polarisable Electrodes, of large form. *Prof. Dr. L. Hermann, Zürich.*

By this apparatus a nerve may be connected with any number of non-polarisable electrodes in a small space, for instance, in the wet chamber of a myograph. The ends of the zinc wires, well amalgamated, receive a covering of clay, mixed with saturated solution of sulphate of zinc, and above this a small quantity of clay mixed with 0·6 per cent. solution of chloride of sodium.

3790a. Becquerel's Thermo-Electric Apparatus for Physiological Purposes. *M. Ruhmkorff.*

3791. Electric Excitors. *T. Hawksley.*

3792. Daniell's Constant Current Batteries for Clinical use. *T. Hawksley.*

3793. Dr. Herbert Tibbitt's Constant Current Batteries and Induction Apparatus. *T. Hawksley.*

3793b. Physiological Recording Apparatus, capable of moving at any speed from three inches to six feet per minute. *Dew. Smith.*

3793a. Electro-Medical Pocket Case.

M. Trouvé, 6, *Rue Thérèse, Paris.*

This contains a battery, an induction coil, and all the accessories used in the practice of electro-therapeutics. (See pamphlet of Dr. Althean, translated by Dr. Davin, Paris, Delahaye.)

3793b. Large Electro-Physiological Apparatus.

Messrs. Trouvé & Onimus. *M. Trouvé*, 6, *Rue Thérèse, Paris.*

This apparatus, intended for electro-therapeutics, is at the same time very valuable for physiological experiments; it is the only one that produces induced currents strictly co-equal, whatever their number. In a given time, it shows instantaneously, and at will, the exact number of interruptions of the current corresponding with the electro-muscular shocks desired to be produced per second. It unites all the conditions requisite for making an exact study of the electro-physiological phenomena, and enables the progress of tetanus in a muscle to be observed.

3793c. Electric Exploring-Extractor.

M. Trouvé, 6, *Rue Thérèse, Paris.*

This serves to diagnose the presence in the organism of any foreign substance, metallic or otherwise, its nature, whether lead, copper, iron, wood, stone, &c.; the direction it has taken, its depth, and thus to facililate its extraction.

3793d. Portable Electro-Therapeutic Apparatus, with equal and continuous Current.

M. Trouvé, 6, *Rue Thérèse, Paris.*

This apparatus, specially intended for electro-therapeutics, is composed of:—

1. A battery of 80 elements, simply moist.
2. An apparatus for graduating the tension of the battery, and altering the direction of the current.
3. A galvanometer intended to register the passage of the current; the whole enclosed in a very portable case. Each element is constituted similarly to battery No. 3793g.

3793e. Apparatus for Galvano-cautery, by G. Trouvé.

M. Trouvé, 6, *Rue Thérèse, Paris.*

This apparatus, specially intended for surgical operations, takes up a very small space, and is composed of movable elements enabling the practitioner to replace by himself, without the help of a specialist, the carbon and the zinc. The cauteries resulting therefrom are isolated by fuzed porcelain, which serves to resist all temperatures and all causes of deterioration.

3793f. Hermetical Battery, by G. Trouvé.

M. Trouvé, 6, *Rue Thérèse, Paris.*

This battery works only when reversed or placed horizontally; the zinc and carbon of which it is composed take up only the upper part of the sheath, made of hardened india-rubber; the other half, the lower, contains the stimulating liquid, water and bi-sulphate of mercury. This battery works the electro-medical case by the same inventor, as also his electro-physiological apparatus and his electric exploring extractor.

3793g. Moistened Battery, with constant Action.

M. Trouvé, 6, Rue Thérèse, Paris.

This battery is composed thus:—Between two discs, one made of copper the other of zinc, forming the two electrodes, are piled rounds of blotting paper. The lower half of these rounds is previously saturated with sulphate of copper, the other half with sulphate of zinc. It is continuously uniform, and lasts a long time. It is applied with great efficacy to electric clockwork, to telegraphy in general, and to all electrical apparatus having a resisting circumference. Moreover it forms part of several apparatus exhibited by the same inventor, particularly of the "military telegraph," the "apparatus with continuous current," &c., &c., &c.

VIII.—APPARATUS FOR INVESTIGATING THE FUNCTIONS OF MUSCLES AND NERVES.

3794. Muscle Telegraph. *T. Hawksley.*

3795. Apparatus for investigating the **action** of **Poisons** on **Muscles.** *T. Lauder Brunton, F.R.S.*

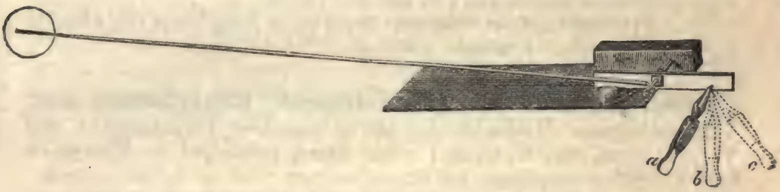
3796. Double Lever Apparatus for demonstrating the movements of the auricles and ventricles.

T. Lauder Brunton, F.R.S.

3797. Apparatus for demonstrating the influence of **Heat and Cold** and the **action of Poisons on the Frog's Heart.**

T. Lauder Brunton, F.R.S.

The fact that heat accelerates and cold retards the pulsations of the heart is one of such fundamental importance, both in regard to a right understanding of the quick pulse, which is one of the most prominent symptoms of fever, and to a correct knowledge of the proper treatment to apply when the heart's action is failing, that for the last year or two the exhibitor has been accustomed to demonstrate it as a lecture experiment. The apparatus used is exceedingly simple, but it answers its purpose well, and by its means the pulsations of the frog's heart can be readily shown to several hundred persons at once. It was exhibited at the meeting of the British Medical Association in London more than two years ago, and a description of it appeared in the "British Medical Journal" for August 23, 1873; but as there is reason to believe that few physiologists have seen either the instrument or its description, it may not be amiss to add a few words regarding it here. It consists of a piece of tin plate or glass three or four inches long and two or three inches wide, at one end of which an ordinary cork, cut square, is fastened with sealing-wax in such a manner that it projects half an inch or more beyond the edge of the plate. This serves as a support to a little wooden lever about three inches long, a quarter of an inch broad, and one-eighth of an inch thick. A pin is passed through a hole in the centre of this lever, and runs into the cork, so that the lever swings freely upon it as on a pivot. The easiest way of making a hole of the proper size is simply to heat the pin red hot, and then to burn a hole in the lever with it. To prevent the lever from sliding along the pin, a minute piece of cardboard is put at each side of it, and oiled to prevent friction. A long fine bonnet straw or section of one is then fastened by sealing-wax to one end of the lever, and to the other end of the straw a round piece of white paper, cut to the size of a shilling or half-crown, according to convenience, is also fixed by a drop of sealing-wax. The pin, which acts as a pivot, should be just sufficiently beyond the edge of the plate to allow the lever to move freely, and the lever itself should lie flat upon the plate. Its weight, too, increased as it is by the straw and paper flag, would now be too great for the heart to lift, and so it must be counterpoised. This is readily done by clasping a pair of bull-dog forceps on the other end. By altering the position of the forceps the weight of the lever can be regulated with great nicety. If the forceps are drawn back as at *c*, Fig. 1, the flag is more than counterbalanced, and does not rest on the heart at all, while the position *a* brings the centre of gravity of the forceps in front of the pivot, and increases the pressure of the lever on the heart. The isolated frog's heart is laid under the lever near the pivot, and as it beats the lever oscillates upwards and downwards. If the tin plate be now laid on some pounded ice, the pulsations will become slower and slower, and if the room be not too warm the heart may stand completely still in diastole. On removing the plate from the ice the pulsations of the heart become quicker. If a spirit lamp be now held at some distance below it, the heart beats quicker and quicker as the heat increases, until at last it stands still in heat tetanus. On again cooling it by the ice its pulsations recommence. At first they are quick, but they gradually become slower and slower. On again applying the spirit lamp they become quicker, and by raising the temperature sufficiently the heat tetanus is converted into heat rigor. Then no application of cold has the slightest effect in restoring pulsation.



Not only the effects of heat and cold, but the effect of separating the venous sinus or the auricles from the ventricle can readily be shown with this apparatus, as well as the action of various poisons. The best for the purpose of class demonstration is muscaria. A drop of saline solution containing a little of the alkaloid being placed on the heart, it ceases to beat entirely. If a drop of atropia solution be now added, the beats recommence. The exhibitor has seen them do so on one occasion after they had entirely ceased for four hours. When used for demonstrating the action of poisons the wooden lever should be covered with sealing-wax, so as to allow every particle of the poison to be washed off it, and thus prevent any portion from being left behind and interfering with a future experiment. By attaching a small point to the end of the straw in place of the paper flag, tracings may be taken upon smoked paper fixed on a revolving cylinder.

3798. Rosenthal's Rotating Myographion, constructed by Th. Edelmann, of Munich. *Prof. Rosenthal, Erlangen.*

This myographion, lately constructed by the exhibitor, and not hitherto described, consists of a large glass plate, which is swiftly rotated round a horizontal axis, by a weight. As soon as the desired velocity is attained, the glass plate is slightly displaced parallel to itself in the direction of its axis. It makes exactly one revolution in its new position, and then returns of itself to its original position in order to keep on rotating. Whilst this one revolution is taking place the excitation and contraction curves are marked by a very simple mechanism. The time of duration can be exactly determined by a simultaneous tracing of a tuning fork curve. For investigations on reflex action, especially for measuring the time of the (so called by the exhibitor) "querlictung" (cross conduction), a contrivance is made by means of which two muscle curves can be simultaneously traced.

In order to determine very exactly the point at which the contraction curve commences, the movement of the muscle is very considerably magnified. As the form of the muscle curve given by this apparatus cannot be depended on, it will not serve for studying its actual details.

The time of revolution of the glass plate may vary from two to half a second. It was impossible to measure with any apparatus hitherto constructed a space of time of such length with sufficient rapidity.

The linear velocity of the instrument revolving at its quickest rate amounts to about 2,500 mm. in a second; values of 0·001 second can thus be easily measured.

3799. Methods of Physiological Experiments and Vivisections. Methodik der physiologischen Experimente und Vivisectionen, von E. Cyon; with Atlas, published by Ricker, of Giessen and Petersburg, 1876.
Physiological Institute, Leipzig (*Prof. Kronecker*).

3800. Apparatus for demonstrating the Pulsations of the Frog's Heart, constructed by E. S. Stöhrer.
Physiological Institute, Leipzig.

3801. Canula for the frog's heart apparatus, constructed by Osw. Hornn. *Physiological Institute, Leipzig.*

3802. Pendulum Commutator, constructed by Baltzer and Schmitz. *Physiological Institute, Leipzig.*

3803. Double Myoscope for the examination and demonstration of the laws of muscular contraction.
Physiological Institute, Prague.

The apparatus allows two nerves to be placed in a damp chamber, at the same time in opposite directions, and to be traversed by the same electrical current. The contractions of the muscles connected with them may be read on two dials.

3803a. Dr. Sibson's Improved Gastric Canulæ.

3804. Professor Foster's Levers for recording the **Movements** of the **Muscles, Nerves, &c.** *T. Hawksley.*

3805. Different Modifications of the **Spring Myograph** of Du Bois-Reymond. *Prof. Theodore Schwann, Liége.*

A diapason or tuning fork is added, with a hammer to make it vibrate. By turning the handle placed on the left-hand side the hammer is freed in the first instance, and in the following moment the blackened glass plate. Excitation is caused by means of an induction coil. Previous to the freeing of the glass plate, and at the commencement of its motion, the current from the pile is interrupted, because it has to pass through the small insulated spring placed underneath the frame, and through the frame itself. But the latter has fixed to its under edge, on the right-hand side, a small ivory plate, which interrupts the metallic continuity. The excitement takes place just as the frame commences, in its motion, to touch with its brass surface this spring. An instrument fixed to the rod which carries the muscle enables the horizontal and the curved line of the muscle to be traced during the same experiment.

3806. Muscular Balance.

Prof. Theodore Schwann, Liége.

This apparatus was exhibited to the meeting of German naturalists at Jena in 1836. It is intended to demonstrate that muscular contraction takes place in accordance with the laws of elastic bodies. At that time the means of producing the continuous contraction of a muscle were not known. In order to determine the degree of contraction without a load or with increasing loads, the beam of the balance was lowered by means of a screw until the muscle could scarcely bear the load. "It was the first time," says M. Du Bois Reymond (Mem. de l'Acad. de Berlin, 1859, p. 79), "that an evidently "vital force was investigated in a similar manner to a physical force, and "that the laws of this force were mathematically expressed in figures." The description of the apparatus is also to be found in J. Müller's Physiology, edition of 1840, Vol. II., p. 59.

IX.—ANTHROPOLOGICAL APPARATUS.

3999. Anthropological Instruments.

Messrs. L. Mathieu and Son, Paris.

1. Anthropological truss.
2. Metrical measure, leather, divided into inches and centimetres.
3. Metrical measures, steel, divided into inches and centimetres (2).
4. Double metre, with articulated springs.
5. Two large squares, graduated, by M. Broca.
6. Facial goniometer „ „
7. Median „ „ „
8. Maxima frame.
9. Flexible auricular square, by M. Broca.
10. Plumb line.
11. Dermographic pencils, by Piorry.
12. Pocket dynamometers, by Mathieu.
13. Pneumometer, and pneumodynamometer.
14. Sphygmograph, by M. Marey.
15. „ by Meurisse and Hy. Mathieu.
16. Anthropometer.
17. Graduated plane, by M. Broca.
18. Profilometer, by Sauvage.
19. Directing and exploring square, by M. Broca.
20. Meter, brass.
21. Caliper compasses, by M. Broca.
22. Micrometric caliper compasses, by M. Broca.
23. Cylometer „ „

24. Compasses, with slides, of various shapes.
25. Endometer, by M. Mathieu.
26. Pachymeter, by M. Broca.
27. Craniostator, of the human cranium.
28. „ for comparative anatomy.
29. Orbitostators, with orbital hands.
30. Bi-millimetrical rule.
31. „ label, by M. Broca.
32. Craniophore, by M. Taupinard.
33. „ by M. Broca.
34. Plane, for projections.
35. Craniograph, by M. Broca.
36. Stereograph „
37. Suspensor, wood, with condylus plumb-line, by M. Broca.
38. Do. steel, do. do. do.
39. Cephalometer, by "Antelme," modified by "Bertillon."
40. Millimetric ruler.
41. Tracing glass.
42. Diopter, by "Wirsig."
43. Camera, "Wollaston's."
44. Diagraph, by "Tavard," modified by Broca.
45. Designer, by Broca.
46. Pantograph.
47. Parietal toniometer, by M. Quatrefages.
48. Occipital level, by M. Broca.
49. Arteria basileris level, by M. Broca.
50. Occipital toniometer, with dial, by M. Broca.
51. Do. do. rectangular, by M. Broca.
52. Caliper compasses, treble-armed, by M. Broca (2).
53. Auricular toniometer, treble-armed, by M. Broca.
54. Cephalic fan, by Second.
55. Rhinometer.
56. Intra-cranium holder.
57. Sphenoidal key.
58. Optical probe.
59. Turisk key.
60. Acoustic intra-cranium probes (2).
61. Optical-occipital probe.
62. Double disk for reconstructing compasses.
63. Cranioscope, by M. Broca.
64. Pivot, by Charles Bell.
65. Frame, by Pierre Camper.
66. Double frame, by Luca.
67. Frame, by Leach.
68. Craniometer, by Barclay.
69. Craniometer, by Bernard Davis.
70. Do. by Busk.
71. Toniometer, by Morton.
72. Apparatus, by Mantegazza.
73. Spindle.
74. Standard litre measure.
75. Half litre measure, graduated.
76. Funnel, with its operculum.
77. Double litre measure.
78. Shaft (*or handle*).

X.—SPECIAL COLLECTIONS.

PHYSIOLOGICAL AND OPHTHALMOLOGICAL INSTRUMENTS CONTRIBUTED BY THE PHYSIOLOGICAL LABORATORY AND OPHTHALMOLOGICAL SCHOOL AT UTRECHT.

a. MICROSCOPY.

3951. Moist Chamber for micro-biological researches.

Prof. Engelmann, Utrecht.

Metallic box, length 80 mm., width 40 mm., depth 7 mm., thickness of the plates 8 mm., bottom, a glass plate. Lid with central opening 15 mm., diameter closed hermetically by a glass cover.

Drop with object to be placed underneath the covering-glass. Some drops of water on the glass bottom keep the chamber moist. The lid is pressed against the upper surface of the chamber by two steel springs. If air-tight closing is required the edges of the lid are greased. Each of the small sides of the chamber is perforated by a metallic tube, 30 mm. long, 4 mm. wide, for the entrance and escape of gases. To investigate the influence of electric currents on the object, which is placed in the moist space filled with air or any other gas, a lid of ebonite is used; it is furnished with two metal binding screws in which the wires are fastened. From each of the screws on the inferior surface of the lid a movable platinum wire conducts to the drop.

In order to examine the influence of changes of temperature and of higher temperatures a similar lid is used, but furnished with a single platinum wire combining the two screws and passing through the drop. This wire is heated by a galvanic current. By modifying the intensity and duration of the current, fluctuations of temperature of any desired magnitude and velocity can be produced in the preparation. To prevent evaporation of the drop when heated it is also covered underneath with a glass.

(Onderzoekingen gedaan in het physiologisch laboratorium der Utrechtsche Hoogeschool. Tweede Reeks, I. 1868, p. 140, &c., Pl. VIII.)

b. REGISTERING INSTRUMENTS.

3952. Set of Tympana for receiving the impressions of movements and communicating them by air-transmission to the cardiograph (modified stethoscope of König).

Prof. Donders, Utrecht.

On the rim of a hollow brass basin are fastened two elastic membranes, the outer membrane convex, the inner membrane concave, owing to the air between them. Close to the rim of the basin a tube *a* conducts into the space between the two membranes. In the centre of the basin (or elsewhere) a tube *b* conducts into the space between the basin and the inner membrane. On sucking at the latter tube, *b*, the inner membrane falls against the basin; on closing now the first tube *a*, and ceasing to suck, the space between the two membranes assumes the form of a bi-convex lens. With two india-rubber lengths fastened on the tubes *c*, for the ears, these instruments are excellent stethoscopes.

The special office of the tympana is to receive the impressions of movements (beating of the heart, pulsation of the carotid artery, respiration, &c.) and to communicate them by air-transmission to the cardiograph. (Compare the curves.)

3953. Chronoscopic Tuning Forks. Set of 4 tuning forks, with 10, 25, 50, and 100 vibrations per second, to be used as chronoscopes; they have a long, very pliable, flat spring, movable in its plane and perpendicularly on it, in order to be easily applied to the cylinder. *Prof. Donders, Utrecht.*

3954. Direct registering Levers (large size) attached to lead wires. *Prof. Donders, Utrecht.*

Very light registering levers with a pin (aluminium or cork) resting on the moving object (a contracting muscle, fontanelles, &c.). Two levers, one with a doubly bent pin, fixed on the same stand, can register two movements on the same cylinder, one immediately below the other (the contractions of the auricle and ventricle of the heart of a frog). Comp. Nuël. Onderzoekingen gedaan in het physiologisch laboratorium te Utrecht, Ser. 3, T. 11. p. 292, and Pflüger's Archiv. B. ix. S. 86.

3955. Apparatus for verifying the **Transmission** of **Movements** by **Air,** an india-rubber tube, and a **Marey's Cardiograph.** *Prof. Donders, Utrecht.*

On a horizontal revolving axis is fixed an eccentrically ground brass disc, which moves a metallic spring placed underneath it. This spring registers its movements on a revolving cylinder, and at the same time presses on a tympanum, which communicates through an india-rubber tube with a Marey's cardiograph. If the cardiograph is made to register on the cylinder immediately under the spring, both curves may be compared. When the disc rotates slowly both curves are alike; with increasing velocity the difference augments. (Compare the curves; some are an imitation of physiological curves.)

3956. Brondgeest's Pansphygmograph. To register the movements of respiration, the beating of the heart, and the pulse of different arteries. *Dr. Brondgeest, Utrecht.*

The little box contains:—

1. Cylinder, with internal spring, to be wound up by the hand.
2. Two Marey's sphygmographs to register on the blackened cylinder simultaneously respiration and pulse curve.
3. Little box with pens, to register, if desired, with ink on white paper.
4. A large tympanum, to register respiration, to be fastened with a tape round the chest or stomach.
5. Tympanum, with wooden plate and pin enclosed in a hoop, to be applied on the heart or on an artery.
6. Glazed papers for the cylinder.
7. Curves of respiration and pulse obtained simultaneously with the instrument.

c. CIRCULATION AND RESPIRATION.

3957. Scheme of the Circulation of the Blood (for instruction). *Prof. Donders, Utrecht.*

An elastic bag with valves sucks water up from a vessel. By repeatedly pressing on the bag (with a lever) undulations are produced either in a glass or into an elastic tube, producing an interrupted or a continuous flowing out. On a long bent elastic tube the simultaneous existence of streaming and propagation of waves is further shown, and by means of two little springs on adjoining places of the tube the velocity of propagation of the wave is demonstrated, and if desired registered (also with different pressures indicated by a manometer). The tube at the same time offers an opportunity for auscultation before and behind a dilatation. (Compare Donders, Physiologie des Menschen. Leipzig, B. I, p. 78. Zweite Ausgabe, 1859.)

3958. Scheme of the relations of **Pressure** in the mechanism of **Respiration.** *Prof. Donders, Utrecht.*

A glass cylinder (thorax), closed underneath by an elastic membrane (diaphragm), at the top by a stopper with three openings: 1st, for a tube (trachea) with india-rubber bladder (lungs) ; 2nd, for a manometer, communicating with the space in the cylinder ; 3rd, for a tube to regulate the pressure of the air in the thorax. This pressure is made negative, as it is in reality ; which causes the air to enter the india-rubber bladder, and the diaphragm to become convex upwards. By pulling the diaphragm down (inspiration) the pressure in the thorax decreases and the lung is more distended ; the resistance of the lung is the negative pressure indicated by the manometer. Instead of an india-rubber bladder a fresh lung of a dog or of a rabbit may be used. The space in the cylinder outside the bladder is of no consequence, as not modifying the pressure on the inner surface of the wall.

d. PHYSIOLOGY OF MUSCLES AND NERVES.

3959. Electrodes, with moist chamber for physiological researches. *Prof. Donders, Utrecht.*

a. Non-polarisable, consisting of glass tubes, at the thin bent end having an aperture closed by moist salt-clay, continued in the lower part of the tube; on this clay the nerve is spread. The tube is further filled with a solution of sulphate of zinc, wherein is a rod of amalgamated zinc.

1. Four of these electrodes on a stand between a vice reaching into a moist chamber of glass, two for a polarising current, two for a stimulating current on the extended nerve. (Compare Donders, Onderzoekingen gedaan in het physiologisch laboratorium, Ser. III., I. p. 1, 1873, and Pflüger's Archiv für Physiologie, Bv., p. 1.)
2. Four coupled with changeable distances.

b. Ordinary. A set of rods of zinc or platinum of various forms fitting into the same insulating glass tubes.

3960. Small round Muscle-Chamber, with non-polarisable electrodes and registering lever. *Prof. Engelmann, Utrecht.*

Bottom, an ebonite disc 50 mm. diameter. Lid, a glass shade perforated at the top, consisting of two halves, one furnished with a handle.

Electrodes, two bent glass tubes ; the vertical arm perforates the bottom of the chamber, and is at the top filled with clay impregnated with a solution of sulphate of zinc. Through the horizontal arm an amalgamated zinc rod soldered to a conducting wire is pressed into the clay. The openings of the tubes in the chamber are covered with salt-clay. Between them the preparation (heart, gastrocnemius, etc.) is put, whose contractions (increase in thickness) can be registered by a lever attached by its axis to a lead wire, and resting on the preparation by means of a vertical pin passing through the central opening in the lid of the chamber. The whole movable on a stand.

3961. Gas-Chamber for electro - physiological experiments particularly with living membranes. *Prof. Engelmann, Utrecht.*

The bottom of the chamber is an ebonite disc, diameter 13 cm., thickness 13 mm., resting on three small feet. Lid, a glass shade, height 12cm., diameter 11 cm., with a broad flat ground rim resting in a groove of the ebonite disc; through the perforated neck a thermometer can be introduced.

On the bottom of the chamber 6 binding screws, each separately in electrical connexion with corresponding binding screws on the outside of the chamber.

Inside the chamber, between the binding screws the object-support is placed, an ebonite plate furnished with :

1st. A central vertical vice to fix a horse-shoe cork frame upon which the animal membrane is spread.

2nd. On each side a glass pillar to fasten the electrodes.

To conduct the electric currents from the preparation small tubular non-polarisable electrodes are used; they are attached to lead wires and each connected by a very thin wire with one of the screws.

The other screws are to conduct electric currents, either to stimulate the object or to warm it by galvanism.

Two bent glass tubes, conducting through the bottom into the chamber, for the entrance and outlet of gases.

(Onderzoekingen gedaan in het physiologisch laboratorium der Utrechtsche Hoogeschool. Derde Reeks, II. 1873, p. 9, &c., Pl. I.)

3962. Isochronoscope. *Prof. Donders, Utrecht.*

A brass lever has at one extremity a registering spring and at the other extremity a peg. On pressing the lever down with the hand, the spring registers the instant at which the peg, touching the mercury, closes the circuit (white electrodes). At this instant, the physiological or psycho-physical effects of this currrent, in all kinds of experiments of irritation, are registered on the same cylinder. Underneath the lever are two electro-magnets. When the current (green electrodes) passes, the lever is pulled down. This current is used either to note certain periods of time, as seconds, on the cylinder, or, by means of a more equal closing of the circuit, to obtain greater equability of the irritating current than can be obtained by the hand. The equable breaking of the circuit is then secured by means of a spring under the lever.

3963. Apparatus for the **Determination** of the **Coefficient** of **Elasticity** of the **Living Muscles** in **Man.** (Compare Mansvelt, Elasticiteit der Spieren. 1860. Diss. inaug. Utrecht, 1863.) *Prof. Donders, Utrecht.*

A vertical wooden board, sliding up and down in a stand with foot, has on its upper side a little sliding beam, and on its surface two recesses, which are the centres of two graduated arcs. With the face directed towards the profile of the board, the operator leans with the shoulder against an extremity of the cross beam and softly presses the internal condyles of the humerus into one of the recesses. The humerus has a vertical position ; the forearm is stretched either horizontally at 0°, or above or below this position, and a weight suspended by a thread to a band round the wrist. On cutting this thread the forearm springs up, and the number of degrees is read off.

From different data the length of the muscle before and after the cutting of the thread and the action of the weight may be calculated, whence may be inferred the lengthening of certain muscles by definite weights at definite degrees of fatigue. One edge of the board is designed for the experiment with the left, the other for the experiment with the right, arm.

e. Physiological Optics.

3964. Double Spectacles, for the determination of refraction (Handbuch der Augenheilkunde von Saemisch und Graefe, III., p. 50). *Dr. Snellen, Utrecht.*

This is an opera-glass in the form of a pair of spectacles, consisting of a pair of negative glasses of one inch focal distance, and in front of these a pair of positive glasses of two inches focal distance. On changing the distance of the positive and negative glasses a hand is made to move on a disc furnished with a scale, which indicates the refraction of the system corresponding with the different degrees of sliding. To be had from R. Jung, optician, Heidelberg.

795. Phakometer (Snellen), for the determination of the power of lenses (by the method of placing object and image at equal distances from the lens). *Dr. Snellen, Utrecht.*

The object (points of light on ground glass) and the screen upon which the image is received are moved in a perfectly similar manner, but in opposite directions, each by a sliding steel spring.

For the determination of weak lenses, two auxiliary lenses, No. 2·75, are placed one on each side of the lens examined (at a distance of 24·33 mm. measured from centre to centre).

The screen which receives the image moves alongside a scale, marked at each double focal distance of the system of the three lenses obtained by calculation for the lenses commonly used in ophthalmological practice. Within $\frac{1}{20}$ "dioptrie" one can with sufficient accuracy estimate how much the lens examined differs from the powers marked on the scale.

The image having constantly the same magnitude, precise adjustment is easy. The screen carries a diagram of the image. If the image of the points of light cover this diagram, the centre of the glass will coincide with the diameter of the instrument. Not only the focus, but also the centre can be determined directly.

The scale may be controlled at any time by determining the strong glasses directly, the auxiliary lenses being removed. Then the double-focal distance is to be taken from the corresponding principal plane to the point where the image is formed.

The instrument as yet is only adapted for symmetrical (bi-convex) lenses. In order to determine plano-convex or periscopic glasses, it will be best to place two glasses of equal power one against the other, so as to obtain a symmetrical form. According to the calculated principal planes of this system, a scale has to be computed.

796. Lens of Stokes, with constant axis (Snellen); consisting of a negative and a positive cylindrical lens rotating equally, but in opposite directions. (Graefe's Archiv für Ophthalmologie, 1873, XIX. 1, p. 70.) *Dr. Snellen, Utrecht.*

Two cylindrical lenses ($C-\frac{1}{10}$ and $C+\frac{1}{10}$) centred one before the other can be made to rotate equally, but in opposite directions, about an axis perpendicular to the plane of the glasses, by means of two sliding steel springs. The principal meridians of the system here remain in the same direction.

The refraction in the principal meridians changes with the rotation proportionately to the sines of the angle between the axes of the cylinders. The scale which is to be read has been constructed on the rim of one of the glasses. For the determination of the refraction, parallel lines are viewed through this lens of changeable power, the lines are perpendicular to one of the principal meridians, and placed either at a distance or united with the lens in a tube. Manufactured by A. Crétès, optician, Paris.

797. Set of Spherical Lenses, metrical system (by Roulot). *Prof. Donders, Utrecht.*

3965. Cylindrical Glasses (simple cylindrical, bi-cylindrical, and spherico-cylindrical) introduced by Donders (Astigmatismus en cylindrische glazen; Utrecht, 1862). Metrical System by Roulot. *Prof. Donders, Utrecht.*

To detect and correct astigmatism. By turning a very weak cylindrical glass before the eye in a plane perpendicular to the visual line, it will be found that no eye is absolutely free from astigmatism.

3966. Test-types, for the determination of the acuteness of vision. Williams and Norgate, London. *Dr. Snellen, Utrecht.*

With letters and figures of definite magnitude are given, in metrical measure, the distances at which they exhibit themselves under an angle of five minutes. This angle is assumed to be the normal visual angle, and the sight is expressed by $V = \frac{d}{D}$, d being the distance at which the letters are recognised, and D the distance at which they exhibit themselves under an angle of five minutes.

3967. Set of Prismatic Glasses (by Roulot), introduced by Donders. *Prof. Donders, Utrecht.*

Besides their application in investigating and compensating anomalies of the eye, they are used to demonstrate:

a. The influence of the tendency to maintain binocular single vision on the movements of the eye.
b. The maximum of divergence of the visual lines.
c. The faculty of equal accommodation at different degrees of convergence.
d. The apparent angle between equally directed meridians of the two eyes.
e. The want of local sign (Local-zeichen) to distinguish the images of the right and left eye.
f. The actual difference of those images in anisometropia.
g. Pseudoscopy at double vision of horizontal lines.

3968. Microscope, to measure the depth of the chamber of the eye. *Prof. Donders, Utrecht.*

By sliding the whole tube of the microscope we consecutively adjust for—*a*, surface of the cornea, *b* iris, and *c*, reflex image; the reading from *a* to *b* is the apparent depth of the chamber, the reading from *a* to *c* furnishes the radius of curvature of the cornea, which enables us to calculate the real depth from the observed apparent depth. On the middle of the objective glass is pasted a very small piece of mirror: the eye observed, on looking in this mirror at the reflex image of a distant flame, is properly directed, and accommodated for distance, and shows to the observer the reflex image for the determination of the radius of curvature of the cornea.

3969. Phacoidoscope. (Anomalies, &c., p. 16.)
Prof. Donders, Utrecht.

A modification of the so-called ophthalmoscope, by means of which Cramer discovered the changes of form of the crystalline lens to be the true principle of accommodation. (Het accommodatie vermogen physiologisch toegelicht. Haarlem. 1853.) The three reflex images are seen in the eye under changeable angles, as the eye accommodates itself alternately to a distant and a near object.

3970. Meridian-ring of the Ophthalmometer. (Anomalies, &c., p. 361.)
Prof. Donders, Utrecht.

A flat ring, 388 mm. diameter, upon which three small lamps can be moved; their reflexion-images have been used by Dr. Middelburg for the determination of the radius of curvature of the cornea in all meridians.

3971. Stenopæic Apparatus and narrow slit. (Compare van Wyngaarden, Archiv für Ophthalmologie, I. 1, p. 251.)
Prof. Donders, Utrecht.

3972. Metallic Plates with two openings, **for Entoptic Observation.** (Anomalies, &c., p. 201.)
Prof. Donders, Utrecht.

To determine the position as to depth of entoptic objects (muscae volitantes, black spots, pearly spots, &c.) in the humours of the eye, by the method "à double vue." Those of one eye are projected in the visual field of the other, and the distance of the double images measured with a pair of compasses (sliding compasses).

3973. Optometer. To determine the relative range of accommodation. (On the anomalies of accommodation and refraction of the eye. New Sydenham Society, London, 1864, p. 115.)
Prof. Donders, Utrecht.

An oblong quadrangular board on a stand. The board possesses three grooves with scales, in which a wire optometer or a point can be moved. On the width of the board are two half-rings supporting the glasses, whose relative distance may be regulated by means of screws. Each ring is movable in a circular groove, the centres of the circles coinciding with the centres of motion of the eyes. The position of the eyes can be controlled by small microscopes fixed on the sides of the board, and remains secured by the cheeks resting against two wooden rods. By this contrivance, the distance between the glass and the eye remaining unchanged, the visual line may at any degree of convergence coincide with the axis of the glass. This instrument is used to determine the play of accommodation at every degree of convergence, *i.e.*, curves of the nearest and farthest points, as functions of the convergence (relative range of accommodation).

3974. Simple Phænophthalmotrope (large size for demonstration), to demonstrate movements of the eye according to the law of Listing, and the corresponding rotation. (Archiv für Ophthalmologie, XVI. 1, p. 154.) *Prof. Donders, Utrecht.*

In an outer fixed ring can be turned another ring, representing the principal plane of axes, containing all the axes round which the eye moves out of the primary into any secondary position. Before turning on the intended axis, we put the arms of the cross vertical and horizontal; after the rotation these arms indicate the position of the vertical and horizontal meridians of the eye.

3975. Compound Phænophthalmotrope (large size, for demonstration). *Prof. Donders, Utrecht.*

This instrument, as well as the simple phænophthalmotrope, No. 3974, demonstrates the movements of the eye according to the law of Listing; but can moreover put the line of fixation in any direction by rotation round a vertical and a horizontal axis (Seitenwendung und Erhebung of Helmholtz). The cross then indicates a position of the meridians different from the position obtained by rotation round a single axis according to Listing's law: the difference is the so-called "wheel-rotation" of Helmholtz.

The same instruments (small size), for private study of the movements of the eyes; they enable us to compare the direction of the after-pictures with the direction of the cross in corresponding movements. (Compare: Onderzoekingen physiologisch laboratorium, Utrecht. Cl. S. ii. D. iii. bl. 119, and Archiv für Ophthalmologie B. xvi. S. 160.)

3976. Simple Phænophthalmotrope, small size, for personal use. *Prof. Donders, Utrecht.*

3977. Compound Phænophthalmotrope, small size, for personal use. *Prof. Donders, Utrecht.*

3978. Snellen's Ophthalmotropometer, for determining the movements of the eye to right and left. (Handbuch der Augenheilkunde von Saemisch und Graefe, III. p. 236.)
Dr. Snellen, Utrecht.

This instrument is intended to determine the movements towards right and left of each eye separately, and of both eyes with regard to each other.

It consists principally of two bars rotating about one axis; they form an angle which can be read directly on a graduated arc, attached to one of the bars.

The instrument is to be placed so that the point of rotation of the bars is perpendicularly below the point of rotation of one of the eyes.

For this purpose, the plate upon which the bars lie can slide forward and backward, and also to the right and to the left, independently of the points against which the head rests with the infra-orbital margins.

The eye under examination has to be fixed upon the middle of a telescope carried by one of the bars. By moving the plate to right or left the instrument is adjusted until the eye is in the middle of the field of view of the telescope. Then the bar with the telescope is turned some degrees, and the eye under examination has to be fixed again in the middle of the field of view; if the point of rotation of the eye does not coincide with the point of rotation of the instrument, the eye will now be seen out of the middle of the field of view. By sliding forward and backward until the eye appears again in the centre of the field of view, the instrument is carried into the proper position with regard to the eye.

The following can now be determined—

1. The mobility of each eye outward.
2. The limits of the lateral binocular vision.
3. The convergence of the two eyes in straightforward vision, and at any degree of lateral fixation.
4. The degree of deviation in strabismus.
5. The centre of motion of the eye.

3979. Ophthalmo-statometer, for the determination of the exorbital protrusion of the eye-ball. *Dr. Snellen, Utrecht.*

Two rods, united by a cross rod, are supported on the inner and outer margins of the orbit. From the cross rod a small crank can slide down until it presses softly against the eye-ball covered by the eye-lid. The thickness of the eye-lid is to be subtracted from the reading. The position of the top of the naked cornea may be read directly by means of a sight movable on one of the rods. (Handbuch der Ophthalmologie, Graefe und Saemisch III., p. 199.)

Manufactured by P. W. Hiele, Utrecht.

3980. Instrument for the determination of the **Movements** of the **Head** and **Eye,** in varying directions of the line of fixation. Donders and Ritzmann. (Compare Archiv für Ophthalmologie, XXI., 1, p. 131, 1875.) *Prof. Donders, Utrecht.*

A bent wooden rod has on one end a mouth-piece, on the other an arc (with a sliding sight), movable round an axis passing through the point of rotation of the eye, which point is at the same time the centre of curvature of the arc.

Over the axis of the arc the eye is fixed on a point *a*, then, without moving the head, on a point *b*, to which the sight is made to correspond; now the eye is again fixed upon *a*, and with free movement upon *b*; from the required displacement of the sight we learn how much the head has shared in the movement. If after the free motion the plane of the arc should not pass through *b*, we make it pass through this point, and read off how many degrees we have had to turn.

3981. Apparatus for verifying the **Laws** of **Donders** and **Listing** (hitherto undescribed). *Prof. Donders, Utrecht.*

A bent wooden rod has on one end a mouth-piece and on the other a coloured strip, movable about an axis passing through the centre of movement of the eye.

After fixation in the direction of the axis, directing the eye upon one extremity of the strip, the after-picture is seen in the prolongation of the strip (Law of Listing) in whatever way the line of fixation reaches the extremity (Law of Donders).

From experiments made with lateral inclination of the head, we may learn how far the associated rotary motion interferes with the law of Listing.

3982. Reflecting Lens, with a mouth-piece **for autoscopy of the eye.** Holländische Beiträge zu den anatomischen und physiologischen Wissenschaften, Düsseldorf und Utrecht, 1864, p. 384; and Mulder, Archiv für Ophthalmologie, Bd. XXI., Abth. 1, 1875. *Prof. Donders, Utrecht.*

Principally used to enable the eye, looking at a vessel of the conjunctiva, to observe its own rotations associated with lateral inclinations of the head. (The first application of the method consisting in uniting an instrument with the head, in order to secure the relative direction of the line of fixation.)

3983. Mouthpiece, with two vertical rods. Showing the rotations associated with lateral inclinations of the head and trunk, to be constantly equal for both eyes.

Prof. Donders, Utrecht.

The rods parallel to the apparent vertical meridians, at a distance of 70 mm., produce parallel half images near each other. In all movements of the head the images remain parallel, thus showing the rotations associated with lateral inclinations of the head and trunk, to be constantly equal for both eyes.

3984. Rod, with graduated arc to determine the degree of lateral inclination of the head. *Prof. Donders, Utrecht.*

Seen with parallel visual lines, the rod shows double images of equal direction with the head (to be used in experiments of parallel rotations, &c.)

3985. Apparatus for determining the rotary motion connected with temporary and permanent lateral inclination. Donders and Mulder (Archiv. für Ophthalmologie, XXI. Abth. 1, p. 68, 1875.)

Prof. Donders, Utrecht.

This apparatus consists of (*a*) a head-holder, which, the head being fixed in the primary position, can revolve round a horizontal axis perpendicularly bisecting the basal line, and easily and quickly be secured in every position.

(*b*.) At a distance of some meters a round disc with horizontal light line of gas flames, situated in the principal plane of fixation, and possessing incisions on the rim for stretching diameters. After fixing the eye for some time on the middle of the light line, the gas is shut off, the head with the holder is turned and the latter secured, when the after-picture coincides with the stretched diameter. The difference between the inclination of the head and the inclination of the diameter is the rotary motion.

3986. Volkmann's Discs, united on one plate for the determination of the angle between meridians of apparent equal direction. The distance between the two axes must be equal to the distance of the parallel visual lines of the experimenter.

Prof. Donders, Utrecht.

3987. Volkmann's Discs of Glass, facilitating parallel position of the lines of fixation by looking at a distance.

Prof. Donders, Utrecht.

3988. Stereoscope with revolving mirrors for the determination of the angle between the meridians of apparent equal direction at different degrees of convergence.

Prof. Donders, Utrecht.

3989. Isoscope, to determine the angle of the meridians of apparent vertical and apparent horizontal direction. (Onderzoekingen physiologisch laboratorium, Derde Reeks, III. 2., 45; and Archiv für Ophthalmologie, B. XXI. 3. S. 100.)

Prof. Donders, Utrecht.

The instrument consists of a head-holder and a frame-apparatus. In the holder (on the principle of Hering) as the head turns round the basal line as axis, the eyes retain their places. The frame-apparatus can rotate round the same axis, and consists of a fixed frame and two pairs of movable frames, one pair for nearly vertical, one pair for nearly horizontal threads.

One of the vertical or one of the horizontal threads may have a fixed position; the direction of the other is obtained by turning the frame, until both the threads viewed with the eye appear to be parallel. The angle between them in this position is read on the graduated arc with vernier.

This instrument is used to determine the angle of the meridians of apparent vertical and apparent horizontal direction, either separately or simultaneously, at any degree of inclination of the plane of fixation, and at any degree of convergence of the lines of fixation, either symmetrical or asymetrical, and to investigate, at the same time, how lines or objects in the field of vision influence these angles.

3990. Perimeter Arc, with diagram of the plane of projection, for determining and registering the field of vision. (Handbuch der Augenheilkunde van Saemisch und Graefe, III. p. 57.) *Dr. Snellen, Utrecht.*

A little below the centre of a movable metallic semicircle is a point for the infra-orbital margin to rest against; thus the eye under examination is kept as much as possible in the centre of the arc. Behind the arc a black board is placed, which is marked with meridians from 10° to 10°, showing, as it were, the projected arc with its divisions. The limits of the field of vision determined on the arc are mapped on the black board.

The scheme obtained represents clearly the limits of vision on each meridian.

To be had from D. B. Kagenaar, Utrecht. Its price is 22·50 f. (1*l.* 18*s.*)

3991. Cycloscope of Donders and Küster, to show the direction of the meridians, the great circles, the direction circles, and the parallel circles of the field of vision, (Archiv für Ophthalmologie, B. xxii. 1876.) *Prof. Donders, Utrecht.*

This consists of a chair with head holder, and an arc with passing induction-sparks. The arc shows, by revolving round different axes, the directions of all meridians, all great circles, the direction circles of Helmholtz, and parallel circles by sliding up and down a stand. When in a dark room, the position of the head being well secured, one eye (the other being covered) is placed in the centre of curvature of the arc and fixed, in the primary position, upon a mark, which owing to its being rubbed with phosphorus throws out a faint light; the induction sparks we may fancy to be distant stars, and determine the direction in which they appear. On the bearing of such investigations, compare Helmholtz, Physiologische Optik, § 28, p. 550, and Krüster, *l. c.*

3992. Horopteroscope, for the determination of the line-horopter-plane, at different degrees of inclination of the plane of fixation and at different degrees of convergence.

Prof. Donders, Utrecht.

The horopter-plane (a quadrangular plate) can revolve round the basal line of the head fixed by the mouth-piece; the relative distance of the two horizontal stripes, seen with or without crossed visual lines, determines the convergence; the horopter-plane is now made to incline until the horizontal stripes have one direction, and then turned round a horizontal axis passing through these stripes until the two perpendiculars on the first stripes are also parallel. (By this contrivance we find the position for close work with the hands, which, according to Donders, has in course of time determined the angle between meridians of apparent equal direction.)

3993. Spark-Stereoscope, with coloured lenses, showing stereoscopic vision independent of movement of the eye. Archiv für Ophthalmologie, Band xiii. p. 33. *Prof. Donders, Utrecht.*

A box with two apertures for the eyes. A series of very small induction-sparks is used as object of fixation. Between two electrodes attached to the sliding lid of the box, we may cause a large spark to pass at different distances before and behind the object of fixation. In monocular vision we fail in recognising the place of the large spark with regard to the object of fixation; but in binocular vision, at the first spark we judge correctly. Between the apertures for the eyes are other electrodes. The spark passing between these last two electrodes is out of sight, but its two reflex images are seen on a coloured lens; one image is coloured the other not. In binocular vision, their position with regard to the object of fixation is soon distinguished; but without an object of fixation, many sparks are required for accurate estimation. In general such coloured lenses are very convenient for demonstration and mutual comparison of the reflex images of concave and convex surfaces.

3994. Ptotostereoscope, to determine the relative value of the second eye for binocular vision, constructed upon the principle of Hering. *Prof. Donders, Utrecht.*

The balls made to fall from the curved rod appear at the respective distances under equal angles, and seem to pass with equal velocity through the field of vision, so that every indication for the monocular vision is excluded, and the relative value of the second eye, for stereoscopic vision, can be deduced from the relation between the number of correct and incorrect cases (according to Fechner's method).

3995. Noematachometer. (Onderz. physiol. laboratorium, Ser. 2, II., bl. 92, 1868). *Prof. Donders, Utrecht.*

A vertical board with a central slit for the eyes, above a sliding electro-magnet with a long metallic prism suspended. The prism has in front and behind a pair of sliding arms upon which a rod can rest, and at its back part two small sliding metal wire-frames, which can contain a very small piece of burning coal. On closing the current the prism falls, and is received in a box with asbestos underneath the slit. During the fall, the rods meet respectively a wooden and a metallic arm, and each produces its characteristic sound; the frames with incandescent coal pass the slit one to the left, the other to the right, and one or other at pleasure coloured by a red glass. Thus either two sounds, two lights, or a light and a sound, can be made perceptible with changeable difference of time (by sliding prism, rods, and frames), and in this manner we learn the time between two impressions, with increasing changes (correct and incorrect cases, Fechner) to perfect certainty, which enables us to judge about the priority of two impressions.

f. PSYCHICAL PHENOMENA.

3996. Noematachograph. Registering the time of psychical processes. (Onderzoekingen physiol. laborat. Ser. 2, D., 1st. 21.) Archiv für Anat., u, s. w. 1868. *Prof. Donders, Utrecht.*

The instrument consists of a horizontal cylinder, which, on being turned by the hand, moves in a spiral. The cylinder is covered with smoked paper, upon which a tuning fork with 250 vibrations per second, to be struck by a percussion hammer, registers its vibrations by means of a small steel spring. This tuning fork can slide and rotate on an axis by which it is suspended.

Without any further complication, the cylinder with tuning fork is sufficient for experiments with the simplified phonautograph, whose spring registers its vibrations next to those of the tuning fork. Two persons A. and B. sit before the phonautograph. A. shouts a short vocal sound, B. repeats it as quickly as possible; on the line registered by the spring the instants of the shouting of the sound by A. and B. are visible, and the time can be read on the adjoining chronoscopic curve. The experiments to be made are: *a*. B. knows which vocal A. will produce; *b*. B. does not know which vocal (from two, three, or more) A. will produce; *c*. B., not knowing which vocal he is going to hear, has to respond only upon a certain one, *e.g.*, on *a*. The time for the intervening psychical processes may be deduced from the times ascertained in the experiments *a*, *b*, and *c*.

For other experiments the instrument is more complicated. At one end of the cylinder are two rings partly covered with copper, partly with ebonite. On each ring two pair of electrodes rest; the lower break and close a constant current, the upper an induction current. The electrodes together are attached by a thick glass bar to a horizontal board following the cylinder, moving in a spiral, thus keeping the electrodes on the rings. The induction currents pass the tuning fork. In one series of experiments only the inner ring is used (the outer ring can be moved aside). On this ring quadrants of copper and ebonite alternate. The electrodes rest on copper, the tuning fork is struck, the cylinder moved half a turn; at the instant the lower electrodes leave the copper, the induction current makes a hole in the paper on the chronoscopic curve, and a spark is made visible without being audible, or audible without being visible, or, the spark being neither audible nor visible, a shock is felt. The spark passes in a little box suspended on a cross-bar between electrodes with knobs, which are to be moved so far apart that the passing electricity constitutes only one spark. In order to *see* or to *hear* the spark, a Leyden jar is inserted in the circuit; the shock is *felt* as unipolar conduction without an inserted Leyden jar.

On the stimulus being received, it is responded to by the hand moving a copper arm of a wooden cylinder with registering spring. By this contrivance, under similar objective and subjective conditions, the physiological time (the time between stimulation and response) can be determined alternately for impressions of vision, of hearing, and of touch at various places of the skin.

A dilemma may be put. Electrodes are applied right and left on the skin and the horizontal arm of the wooden cylinder struck in corresponding direction. In a similar manner, by a conventional response, a decision may be made between red and white light. In both cases response may be forbidden for one colour or for stimulation on one side. Instead of responding with the hand, the voice may be used acting on the phonautograph, and the physiological time determined in both cases. On the spark passing in the box, and making transparent letters visible, the physiological time for recognising these letters may be registered and compared with the time for simple light perception, etc.

The second ring has only a small conducting plate, upon which, at the rotation of the cylinder, the constant current is closed and broken, after contact with the electrodes of the induction current has followed. Thus, by sliding this second ring, sooner or later after the first spark, a second is made to pass. perforating the chronoscopic line, and at the same time, either visible in the second compartment of the box, audible, or sensible at another part of the skin. So we learn the time between two impressions on the same sense, or on two different senses, which enables us to judge about the priority.

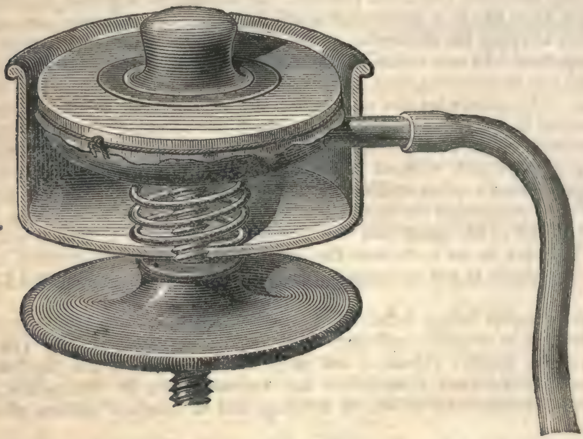
In order to prevent, under all circumstances, the sparks from passing from one ring to the other, a somewhat greater distance between the rings is desirable.

PROFESSOR MAREY'S APPARATUS FOR OBSERVING AND REGISTERING PHYSIOLOGICAL AND MECHANICAL PHENOMENA.

3997. 1. Cardiac sounds for indicating the pressure in the cavities of the heart. A. Sound for the right heart. B. Sound for the left heart. C. Sound for showing negative pressures. D. Sphygmoscope. (The corresponding tracings are given in Plate I., 1–4.

2. Explorator for the heart of the rabbit. (Plates 2 and 2 quater.)

2A. Explorator for the human heart. (Plate II.)



Membrane explorator, for the pulsation of the heart, applicable to man or animals. By turning the regulating screw the button of the explorator may be made to project more or less, thus increasing or diminishing the sensitiveness of the instrument.

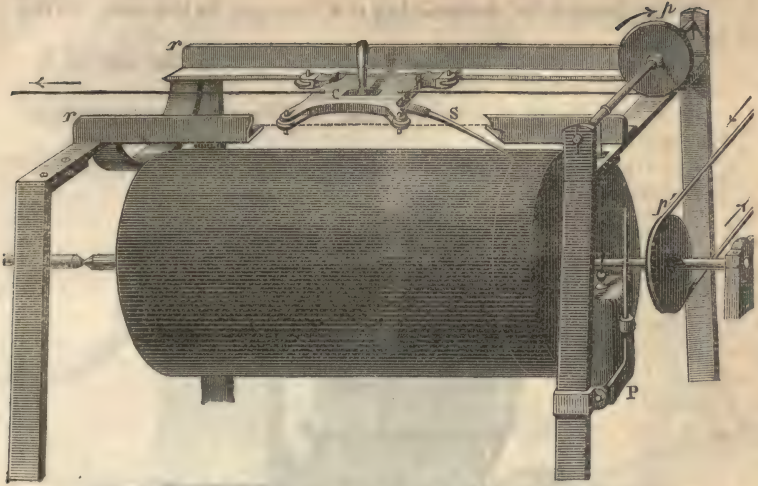
3. Explorator for the pulse (sphygmograph of transmission). (Plate III.)

4. Explorator for the respiratory movements. (Plate IV.)

5. Myographic pincers.

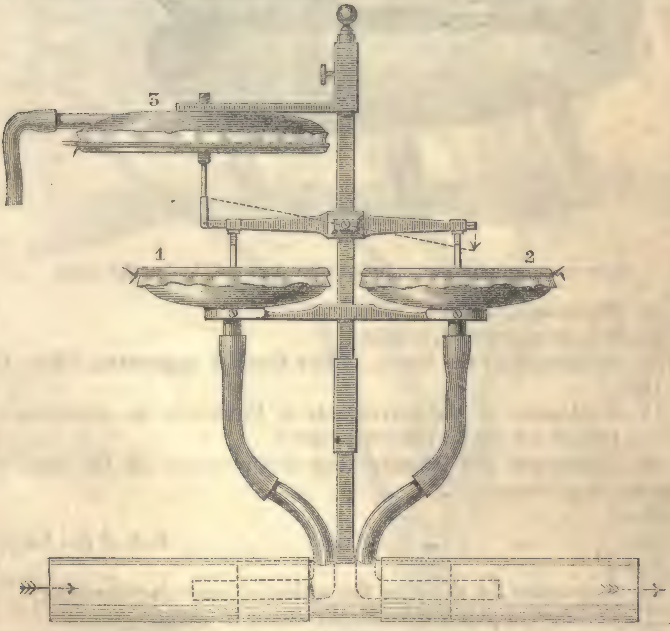
5A. Myographic pincers, another pattern.

6. Explorator for the investigation of to-and-fro movements, such as those of locomotion (of the horse), and of flight (of birds). (Plate VI.)



Apparatus for the graphical representation of any rectilinear motion.

7. Explorator for determining the rapidity of the flow of fluids.



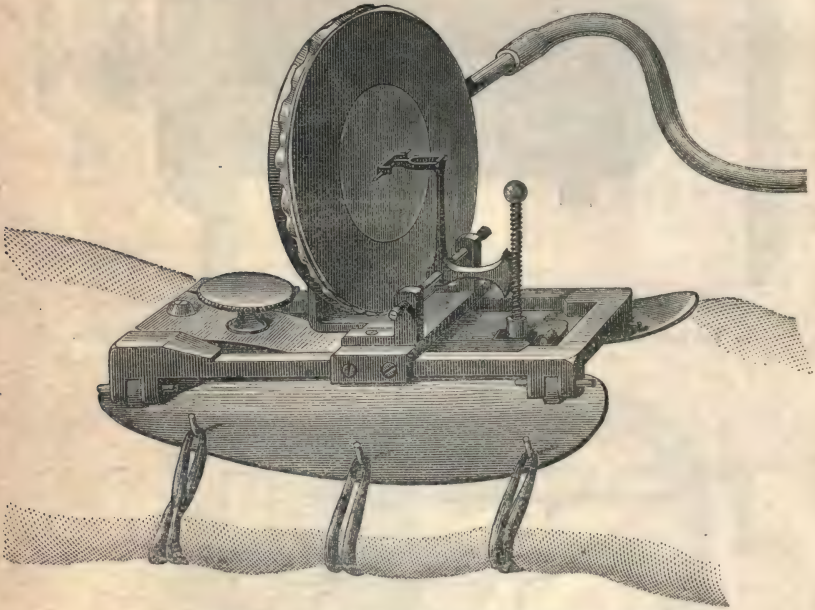
Model of an apparatus for the graphical representation of the motion of a liquid in a tube. or artery.

8. Explorator for determining the changes in the size of the hand.

8a. Explorator for determining the changes in the size of the heart of the tortoise. (Plate 8 and 8 bis.)

9. Apparatus of "Donders" for verifying the correctness of tympana.

10. Myograph for transmission.



Sphygmograph for transmission placed in position on the wrist.

11. Myograph, direct, double.

12. Myograph, direct, single.

13. Myograph of the heart. (For these 3 apparatus, Plate 12 to 12³.)

14. Explorator of the movements of liquids in an elastic tube. (Plate 14 and 14 bis.) (*See opposite.*)

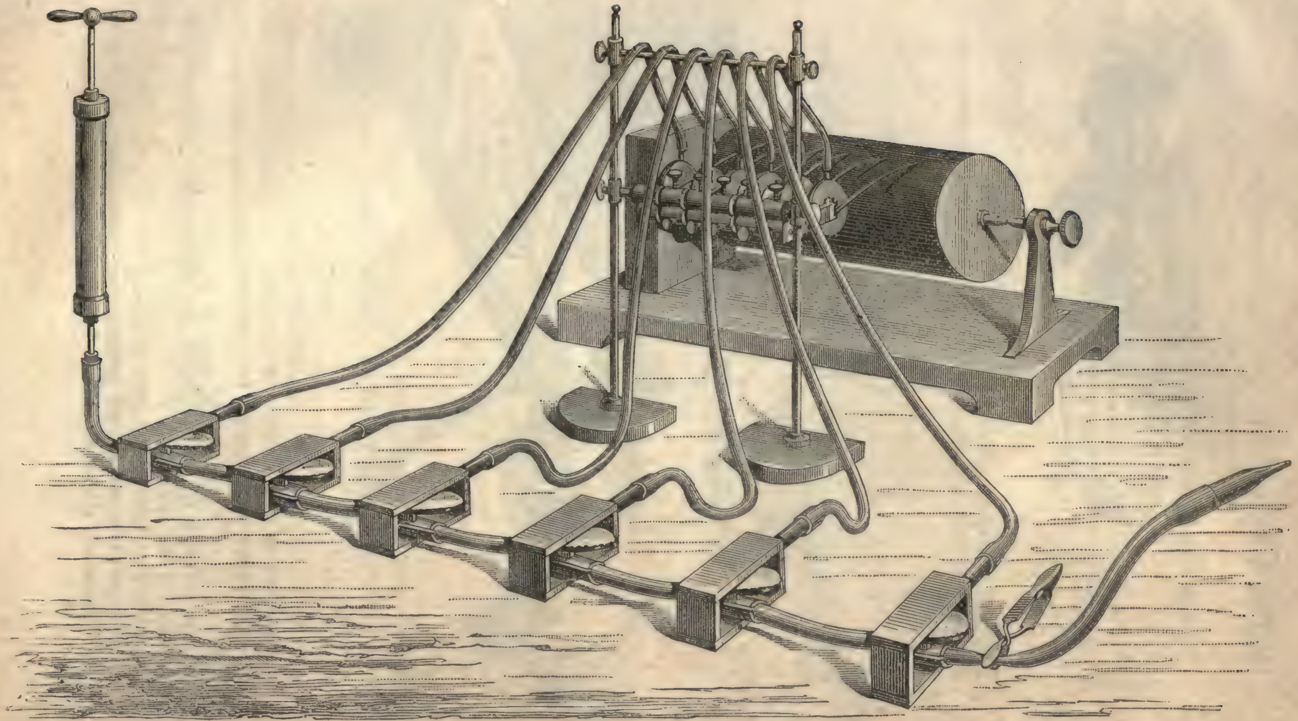
15. Explorator for investigating the pressure of the foot in human progression.

15A.
15B. } " " " " feet of the horse.
15C.

16. Apparatus for showing the action of muscular elasticity.

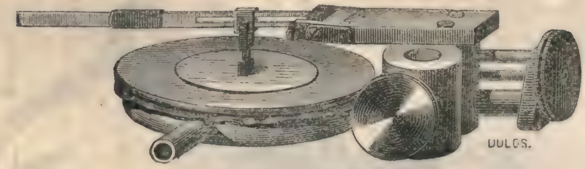
17. Tracing on paper transferred direct to wood.

18. Registering cylinder, with "Foucault" regulator, and rotatory hopper, by Marey.



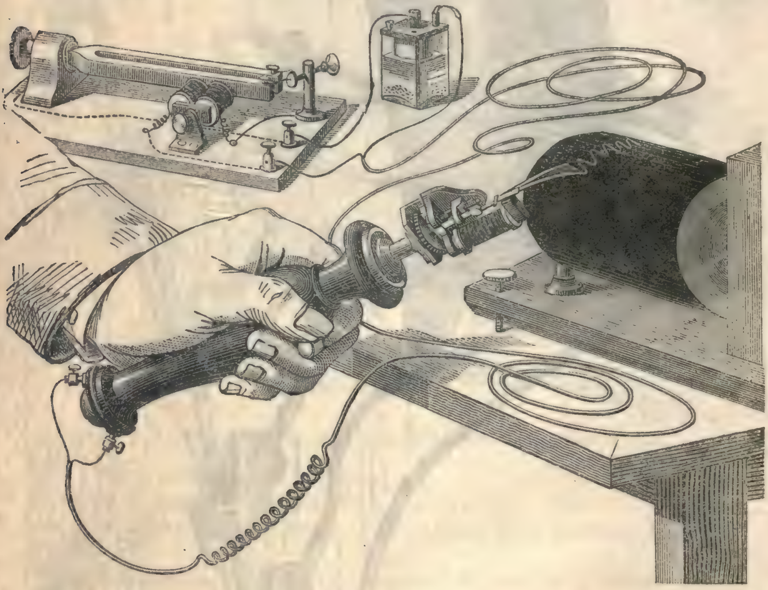
Series of explorators for investigation of a wave of fluid, attached to an equal number of recording lever membranes. Arrangement for the experiment.

19. Tympanum and lever recording instrument.



20. Hæmodromograph, by Chauveau.

21. Portable electric chronograph, giving 100 double vibrations per second.

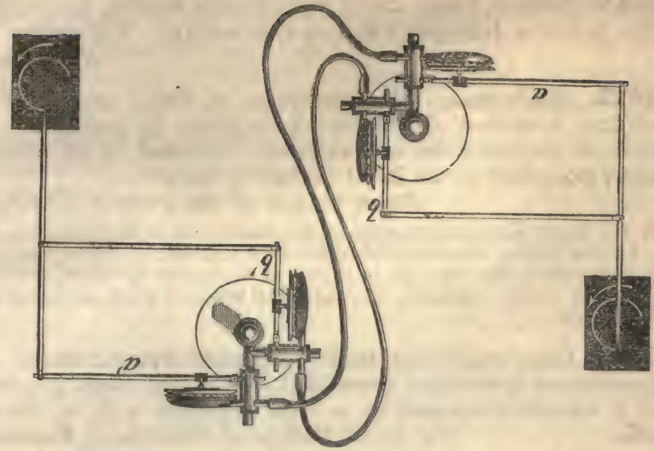


22. Tambours conjugués, for reproducing movements at a distance.

23. Pantograph of transmission, for reproducing movements at a distance. (*See opposite.*)

7. For demonstrating the laws of vision:

Large glass model of human eye; stereoscope and geometrical slides, to show effect of binocular vision.



Pantographe of transmission.

8. Diagrams of—
    - (*a.*) Shadow and penumbra.
    - (*b.*) Lateral inversion of reflected image.
    - (*c.*) Distance of image behind mirror.
    - (*d.*) Refraction by prism.
    - (*e.*) „ „ convex lens and formation of image.
    - (*f.*) „ „ concave „ „ „
    - (*g.*) The human eye.

The foregoing set is contained in a strong case, 24 × 18 × 9 inches, with fittings for facilitating the employment of the apparatus.

Dr. Marey, Professor of the College of France, Paris.

XI.—DIAGRAMS, MODELS, PREPARATIONS, AND OTHER APPLIANCES FOR INSTRUCTION IN BIOLOGY.

3808. Recent Marine Mollusca. Typical collection, comprising 300 genera; to illustrate Woodward's "Manual of the Mollusca," and other works. *R. Damon.*

3809. Land and Fresh Water Mollusca. Typical collection, comprising 155 genera; to illustrate Woodward's "Manual of the Mollusca," and other works. *R. Damon.*

3810. British Marine Shells, illustrative of Dr. J. Gwyn Jeffreys's "British Conchology." 336 species. *R. Damon.*

3811. British Land and Fresh Water Shells, illustrative of Dr. J. Gwyn Jeffreys's "British Conchology." 122 species.

R. Damon.

3812. Skeletons. Two specimens of Manis or Pangolin, exhibiting a method of articulating skeletons, by which all the surfaces of the bones can be examined. Invented by Mr. James Flower, articulator to the Royal College of Surgeons.

Royal College of Surgeons of England.

In the larger specimen the parts of the skeleton are in their natural relation, but any portion which may be required for examination can be removed without disturbing the rest, as is shown in the smaller specimen, which is divided into various segments, the individual bones of which are united by flexible wires.

3815. Case containing twelve **Injected Preparations** by the celebrated Lieberkühn (born 1711, died 1756) ; each preparation is separately mounted in a brass magnifier with an ebony handle. *The Royal College of Surgeons of England.*

The object, which is opaque, is viewed with light concentrated upon it by means of a concave polished metal condenser (known as a "Lieberkühn"), and magnified by a simple lens adapted to a perforation in the centre of the condenser.

3813. Carbon Photographs of microscopic objects for projection by the lantern, photographed by F. J. von Kolkoff.

Prof. D. Huizinga, Physiological Laboratory of the University of Groningen.

3816. Two small Cases with Lieberkühn's Preparations in microscopes.

Royal Museum at Cassel (Director, Dr. Pinder.)

The two collections of *Lieberkühn* have been made in the earlier part of the 18th century. According to *Harting*, the Royal College of Surgeons of England possesses a similar one.

3816a. Microscopical Preparations. No. 1–289.

I. History of the development of the Cephalopoda.
II. Microscopical anatomy of the Tunicata.
III. Histology of the nervous system of the Vertebrata.

Dr. Michel Oussoff, Russia.

3816b. Microscopic Preparations.

Zoology.—Preparations of tissues in their normal, and in their morbid state.

Vegetative physiology.—Elementory organs, cells, vessels, composite organs, epidermis, stems, roots, organs of reproduction.

Medicinal substances.—Stems, roots, barks, seeds, salts used in pharmacy.

Alimentary products.—Flours, feculæ, prepared with the object of defining commercial adulterations.

Textile products.—Prepared with the object of defining commercial frauds. *Eugène Bourgogne, Paris.*

3816c. Large Sections, for the **Microscope,** of various **Anatomical Tissues,** showing variety of methods of histological staining. *Drs. Hoggan.*

3818. Models exhibiting the **Anatomical Symptoms** of **Cattle Disease.** *A. Th. Ferhaar, Utrecht.*

No. 1.—Three cows' eyes :

A. A healthy eye, of which the sclerotic and the accessory eyelid are pale.

B. A healthy eye, in which the same parts are of a brown colour : this is considered as a distinctive mark that the animal is not liable to catch the disease.

C. The eye of a cow attacked by the cattle disease. The red colour of the above-named parts may be noticed.

No. 2.—The extremity of the lower jaw and the inner surface of the lower lip of a cow attacked by the cattle disease. In these an irregular swelling and the difference of colour, as well as the excoriated and lacerated places on the gum, are to be noticed. A part of the same jaw seen inside, having the same symptoms.

No. 3.—The cartilaginous septum nasi of a cow that has died of the cattle disease, seen on the right side. The red colour and violent swelling of the mucous membrane and the great quantity of thick mucus are particularly remarkable ; on the edge of the nostril an affection of the skin and dry crusts of mucus are to be noticed.

No. 4.—The right side of the larynx and a portion of the windpipe of a cow that has died of the cattle disease. The red colour and the swelling of the pyogenic membranes are to be seen.

No. 5.—A portion of the œsophagus (gullet) of a cow that died of the cattle disease. One part of the inner membrane is nearly healthy, the other very red and swollen.

No. 6.—The palate of a cow that has died of the cattle disease.

No. 7.—The end of the abomasum and the beginning of the small intestines of a cow that has died of the cattle disease. The violent swelling, the red colour, the small pyogenic cavities, and the black crusts of blood on the mucous membrane of the stomach are remarkable.

No. 8.—A piece of the small intestines of a cow that has died of the cattle disease, opened and seen inside. The red colour, and the swelling of the mucous membrane, in which Peyerian glands swollen and empty are seen.

No. 9.—A piece like No. 8. Several black spots may be noticed.

No. 10.—A piece like No. 8 and No. 9. Besides the swollen glands the difference of colour may be seen.

No. 11.—A piece like Nos. 8, 9, and No. 10. Here and there a difference of colour is apparent.

No. 12.—A piece like Nos. 8, 9, 10, and 11. The mucous membrane appears thinner and duller.

No. 13.—The end of the small intestines and the cæcum of a cow that has died of the cattle disease, opened and seen inside. The much-swollen folds, the redness of the mucous membrane, as well as the black spots, especially at the point of transition from the small intestines to the large, are remarkable.

No. 14.—The end of the rectum of a cow that has died of the cattle disease, opened and seen inside. The folds of a black colour, and the considerable swelling and redness of the mucous membrane are remarkable.

No. 15.—A piece of the skin of a cow that has died of the cattle disease, taken from the inner surface of the leg. Grey crusts covering the diseased parts of the skin, and between these the fissures in the true skin, are to be noticed.

3819. Skull of Sheep (*Ovis aries*). The bones have been disarticulated and mounted in segments, according to their morphological relations, so that each segment may be removed for lecture purposes. *E. T. Newton, Museum of Practical Geology.*

The following is the order in which the bones are grouped :—

BRAIN CASE.—1st Segment. Basioccipital ankylosed, with two exoccipitals supraoccipital.

2nd Segment. Basisphenoid ankylosed with two alisphenoids; two ankylosed parietals.

3rd Segment. Presphenoid ankylosed, with two orbitosphenoids; two frontals.

NASAL REGION.—Mesethmoid ankylosed, with two superior and two middle turbinals and vomer; two free nasals.

AUDITORY REGION.—Right side. Squamosal, tympanic, and periotic mass. (The periotic bones being ankylosed.)
Left side. Ditto ditto.

FACIAL REGION.—1. The two premaxillæ.
2. Right side. Maxilla, jugal, lachrymal, and inferior turbinal.
3. Left side. Ditto ditto.
4. Right side. Palatine and pterygoid.
5. Left side. Ditto ditto.

FIRST VISCERAL ARCH.—Right side. Ramus of lower jaw and malleus. (The latter, for convenience, is mounted separately).
Left side. Ditto ditto.

SECOND VISCERAL ARCH.—The hyoid, consisting of basihyal, two ceratohyals, two epihyals, two stylohyals, and two tympanohyals. (One of the tympanohyals is left attached to the tympanic bone). The two thyrohyals belong to the third visceral arch, but are mounted here for convenience.

The incus and stapes of each side are mounted separately on account of their small size; the former belongs to the second visceral arch, and the latter is most probably a part of the auditory capsule.

3820a. Collection of Entomological Preparations for the **Microscope,** comprising dissections of insects and whole insects, mounted in Canada balsam. *Frederic Enock.*

Some of these preparations are mounted in a deep cell, and by being treated in a peculiar manner their natural form is preserved, and the *internal* structure of muscles and tracheæ seen in their natural positions.

3821. Objects exhibited by Professor Moser.

The geometrical and perspective drawings, I., II., and III., represent an apparatus for the determination of the products of the respiration and perspiration of animals. The apparatus is arranged at the I. R. Chemico-Agricultural Experimental Institution at Vienna, for experiments on horses, cattle, sheep, and pigs. The plan is that of Professor M. Pettenkofer, of Munich, excepting that for the aspiration of the air, which is the same as that adopted in a smaller apparatus by Professor C. Voit, of Munich. The parts are as follows:—

A, chamber for the reception of the animal during the experiment.

B, tube of tin, for the passage of the gaseous products from the chamber.

C, a vessel in which the gaseous products are saturated with watery vapour.

D, a gasometer in which the volume of the gases is determined.

E, tube through which the measured gases escape.

F, engine (hot air) which, by turning the revolving drum of the gasometer, aspirates the gases through the parts A, D, and, as a consequence, draws fresh air in through the openings in the back of A′.

To ascertain the quantities of carbonic acid, aqueous vapour, and methan (marsh gas) evolved by the animal, the composition both of the gases passing from the chamber A through the tube B and of the fresh air is determined, with regard to their contents of these substances, and the difference shows the quantities of the gases evolved.

For these examinations the apparatus shown on the table G is employed. Aspirating and forcing pumps (*c*, *c*, *c*,) which close with mercury, draw small quantities either of air from B through the tubes *a*, *a*,...or of fresh air through the tubes *b*, *b*,...and force them through the absorption apparatus *d*, *d*,... and *d*1, *d*1, or *d*2, *d*2, to the gasometers *e*, *e*, *e*,...where they are measured.

The motion of the pumps is effected by the engine F by means of the mechanism *o*, *p*, *q*, *r*, *s*. To every absorption apparatus there appertain two pumps which alternately aspirate and force, and four valves with mercury joints (*f*, *f*, *f*...).

The carbonic acid is absorbed by a test solution of baryta in the tubes *d*, *d*, ...and *d*1, *d*1....

The aqueous vapour is determined in the flasks *d*2, *d*2,...which contain pumice stone saturated with sulphuric acid.

The carburetted hydrogen is oxidated by passing over ignited oxide of copper. For this purpose a portion of the air to be analysed is drawn by the pumps through the tubes *g*, *g*, filled with oxide of copper, and placed upon a furnace H. The products of the oxidation, carbonic acid and water, are then conveyed to the absorption apparatus and gasometers.

The drawing IV. represents a similar apparatus, but of smaller dimensions, which also is employed at the I. R. Chemico-Agricultural Expermental Institution at Vienna. Its construction is in the main the same, excepting that the ventilation is effected by the exhausting fanner K. The motion of K and of the pumps (*c*, *c*,) is effected by the mechanism L, which is worked either by a man or by a small water wheel. (The other signs on this drawing IV. correspond with those of the drawings I., II., III.)

The smaller apparatus is used for experiments with poultry, rabbits, and other small animals.

3822. Photographs of Microscopic Objects. Enlarged from negatives by Dr. Maddox, for illustration by means of the lantern. *James How & Co.*

3823. Mounted Preparation to show a method of putting up dried membranous specimens for museums.

Prof. Struthers.

The glass jar is not essential. The wire loop displays and also protects the preparation, and the tube enables it to be turned round on the stand, or to be taken out and held up by the stem for demonstration. Curators of museums may remove the cover and examine the mounting. The specimen is a preparation of the human pyloric "valve."

3823a. Specimens of Linnæus's MS.

The Linnæan Society.

"Iter Dalekarlicum," a MS. journal of a tour made at the suggestion of Governor Reuterholm, in the year 1734, through the provinces of East and West Dalecarlia, by Linnæus himself, accompanied by several students from the University of Upsala, who were devoted to the study of natural history, each student undertaking to record daily his observations on the particular branch assigned to him.

The journal, which is chiefly in Swedish, and does not seem ever to have been published, is illustrated by pen and ink sketches, and accompanied by one engraved and two MS. maps of the district traversed.

3823b. Specimens from Linnæus's Collections.

The Linnæan Society.

a. Zoological.

1. *Mya margaritifera*, and portion of shell with artificial pearls.

In his letter to Haller, dated Upsal, Sept. 13, 1748, Linnæus writes, "At "length I have ascertained the manner in which pearls originate and grow "in shells,* and I am able to produce, in any mother-o'-pearl shell that "can be held in the hand, in the course of five or six years, a pearl *as large* "*as the seed* of common vetch."

2. *Testudo pusilla*, L., native of the Cape of Good Hope. Both specimens named in Linnæus's own hand.

3. *Scomber Chrysurus*, native of Carolina.

* "For this discovery the illustrious author was splendidly rewarded by "the States of the Kingdom."—*Haller*. Specimens of pearls so produced by art in the *Mya margaritifera* are in the Linnæan Cabinet.

"The shell appears to have been pierced by flexible wires, the ends of "which perhaps remain therein."—(Smith's Selection of the Correspondence of Linnæus, II., p. 428.)

In his Memoir of Linnæus, in Rees's Cyclopædia, Sir James Smith, after mentioning that his patent of nobility was confirmed by the Diet in 1762, goes on to state that that august body honoured him with a still more solid reward, upwards of 520*l*. sterling, for his discovery of the art of producing pearls in the river mussel by wounding the shells; but the practice does not seem to have been prosecuted to any great extent.

b. Botanical.

(All glued on paper, poisoned to protect them from insects, and named in Linnæus's own hand.)

1. *Linnæa borealis*, Gron. Named in honour of Linnæus, by his pupil Gronovius.
2. *Sibthorpia Europæa*, Linn.
3. *Browallia demissa*, Linn.
4. *Hebenstretia capitata*, Thunb.

5. *Erinus capensis*, Linn.
6. *Buchnera Asiatica*, Linn.
7. *Pedicularis tuberosa*, Linn.

3823c. Dried Specimens of Plants from the Society's British Herbarium. *The Linnæan Society.*

1. Ranunculus, 17 sheets.
2. Dentaria, 3 sheets.
3. Matthiola, 2 sheets.
4. Linum, 7 sheets.
5. Fragaria, 4 sheets.
6. Oxalis, 2 sheets.

3823d. Specimens of the Linnæan Society's Publications. *The Linnæan Society.*

1. Transactions. 4to. (*Illustrated.*)
   Vol. 19, Part 2, containing papers by—
      Hope on rare and beautiful insects from Silhet.
      Blackwall on British Spiders.
      Quekett on Ergol.
      Forbes on the *Ophiurida* of the E. Mediterranean, &c.
   Vol. 22, Part 4, containing—
      Hooker on the Pitchers of *Nepenthes*, with account of new species from Borneo.
      Hooker on new *Balanophoreæ*.
      Bentham on *Henriquezia*.
      Seemann on *Camellia* and *Thea*.
      Cobbold on new *Entozoa*, &c.
   Vol. 24, Part 1.
      Hooker on *Welwitschia*.
   Vol. 26, Part 4.
      Williamson and *Carruthers* on Fossil *Cycadeæ*.
   Vol. 27, Part 1.
      Welwitsch. Sertum Angolense: s. Stirpium . . . in itinere per Angolam et Benguelam observatarum descriptio, *Iconibus illustrata*.
   Vol. 29, Part 1.
      Col. Grant. Botany of the Speke and Grant expedition from Zanzibar to Egypt.

Transactions. Second Series; in which the two sections, *Zoology* or *Botany*, are published separately.

   Zoology.
   Vol. 1, Part 1, containing—
      Willemoes Suhm, on Atlantic Crustacea from the "Challenger" Expedition.
      Parker on the Morphology of the skull in the Woodpecker, &c.
      Allman on *Stephanoscyphus mirabilis;* the type of a new order of Hydrozoa.
   Botany, Vol. 1, Part 1.
      Miers on *Napoleona*, *Omphalocarpum*, and *Asteranthos*.
      Miers on *Auxemmeæ*.

Transactions. Specimens of papers, from the later volumes, printed off for separate sale.

   Botanical.
      1. *Welwitsch* and *Currey*. Fungi Angolenses (from Vol. 26, Part 1).
      2. *Scott* Tree Ferns of British Sikkim (from Vol. 30, Part 1).

Zoological.

3. *Trimen.* Mimetic Analogies among African Butterflies (from Vol. 26, Part 3).
4. *Murie* on the three-banded Armadillo (Vol. 30, Part 1).

2. JOURNAL, 8vo. The two sections, *Zoology* and *Botany*, published separately. The papers illustrated when necessary.

Zoology, Nos. 60–62, containing—

Allman, on new genera and species of *Hydroida*.

Cobbold on the large Human Fluke (*Distoma crassum*), &c.

Botany.

No. 74. *Berkeley* and *Broome.* Fungi of Ceylon.

No. 82. Contribution to the Botany of H.M.S. "Challenger."

Supplement to Vol. 5.

Anderson. Florula Adenensis; account of the flowering plants hitherto found at Aden.

3824. Entire Plant of *Welwitschia mirabilis*, Hook, fil. Discovered by Dr. Welwitsch, in South-west Africa, in 1859.

Museum, Royal Gardens, Kew.

This plant is the subject of a memoir by J. D. Hooker, M.D., P.R.S., in the Transactions of the Linnæan Society, Vol. XXIV.

3825. Series of Fruits illustrating the variety of form in the **Dalbergieæ,** a tribe of **Leguminosæ.**

Museum, Royal Gardens, Kew.

Described by George Bentham, Esq., F.R.S., &c., in Supplement to Vol. IV. of the Journal of the Linnæan Society.

3826. Fruits illustrating the **Rubiaceæ,** a very large order of tropical trees and shrubs. *Museum, Royal Gardens, Kew.*

The genera of these have been revised and published in Part I., Vol. II. of the "Genera Plantarum," by G. Bentham, F.R.S., and J. D. Hooker, M.D., P.R.S.

3827. Series of Fruits, showing the variation in form and size of the different species of **Eucalyptus,** a genus of shrubs or trees, commonly known as gum trees, almost exclusively confined to Australia. *Museum, Royal Gardens, Kew.*

The species have been described by George Bentham, Esq., F.R.S., in Vol. III. of his "Flora Australiensis."

3828. Fruits and Seeds of plants belonging to the natural order **Bignoniaceæ,** a family of twining or climbing plants or trees. Found chiefly in the tropics.

Museum, Royal Gardens, Kew.

A revision of the genera of this order will appear in the forthcoming volume of the "Genera Plantarum," by G. Bentham, F.R.S., and J. D. Hooker, M.D., P.R.S.

3829. Collection of Fruits illustrating the **Australian Proteaceæ.** *Museum, Royal Gardens, Kew.*

The collection consists chiefly of species of *Banksia* and *Hakea*, both of which are limited to Australia, and have been described by George Bentham, Esq., in the fifth volume of the "Flora Australiensis."

3829a. Model of the **Physiology** of a **Grain** of **Wheat** (30 times magnified). *Doctor Auzoux, Paris.*

3829b. Model of the **Physiology** of a **Small Ear** of **Wheat** (belonging to the Conservatoire des Arts et Métiers).
Doctor Auzoux, Paris.

3829c. Model of **Anatomy** of the **Silk Worm** (belonging to the Conservatoire des Arts et Métiers).
Doctor Auzoux, Paris.

3829d. Model of **Anatomy** of the **Egg** of the **Epyornis.**
Doctor Auzoux, Paris.

3830. Pathological Preparations. A complete set of 24, from the human subject, mounted for the microscope.
Arthur C. Cole & Son.

3831. Physiological Preparations. A complete set of 24, from man and the lower animals. *Arthur C. Cole & Son.*

3832. Educational Preparations. A complete set of 24, for medical students and schools. *Arthur C. Cole & Son.*

3833. Vermiform Appendix, Cæcum, and parts of Small Intestine and Colon of Rabbit (*Lepus cuniculus*), with the Peyerian and also some of the mesenteric glands in connexion with them injected.
The Anatomical Department, University Museum, Oxford.

The ileum and colon lie side by side, the former describing a siphon-shaped curve before ending in a dilatation, known as the "*sacculus rotundus,*" and homologous with the aggregation of Peyerian follicles situated in man just anterior to the ileo-cæcal valve. The *sacculus rotundus* occupies the centre of the preparation; above and a little to the left of it another somewhat similar aggregation of Peyerian follicles is seen just beyond the ileocolic valve. The colon curves backwards externally to and concentrically with the ileum. The cæcum consists of two portions: one larger in calibre, thinner in walls, and sacculated spirally; the other, the homologue of the human "appendix vermiformis," smaller in calibre, but with much thicker walls. Prepared by Mr. Robertson.

3834. Appendix Vermiformis of Rabbit (*Lepus cuniculus*), with a small portion of the cæcum and a larger portion of the small intestine left in apposition with it.
The Anatomical Department, University Museum, Oxford.

The lacteal system has been injected with Berlin blue by the insertion of the point of a syringe into the lacunar system. The injection is seen to have passed into some of the adjacent mesenteric glands. Prepared by Professor Rolleston.

3835. One Longitudinal and two Transverse Sections of the Appendix Vermiformis of Rabbit (*Lepus cuniculus*).
The Anatomical Department, University Museum, Oxford.

The blood vessels have been minutely injected with carmine and the lacteals with Berlin blue. Prepared by Mr. Robertson.

3836. Right Half of the Skull of a Sturgeon (*Acipenser sturio*), macerated, and mounted in the ordinary way.
Prepared by Mr. Robertson.
The Anatomical Department, University Museum, Oxford.

3837. Left Half of the Skull of a Sturgeon (*Acipenser sturio*), stained to show the cartilaginous cranium.

The Anatomical Department, University Museum, Oxford.

This preparation was placed for several hours in staining fluid, which has tinted the cartilaginous cranium whilst leaving the bony elements with their natural white colour. Prepared by Mr. Robertson.

3838. Skull of a Sturgeon (*Acipenser sturio*), stained to show the cartilages.

The Anatomical Department, University Museum, Oxford.

The opercular bones of both sides have been removed, also the shoulder girdle, parietal and frontal bones of the left side, to show the cartilaginous cranium. Prepared by Mr. Robertson.

3839. Set of Wax Models, to illustrate the **Development** of the **Trout** (*Trutta fario*), containing 21 preparations, including 7 sections. The preparations can be viewed by transmitted light. Magnified 30 diameters.

Dr. A. Ziegler, Freiburg, Baden.

This series is the latest work of the exhibitor, and the 21st series of his scientific wax preparations for illustrating biological facts, and particularly the changes during development. These wax models are copied from nature, and enlarged so as to be useful for teaching purposes. Compare the accompanying prospectus and account of physiological preparations in wax for the use of English readers.

A full account of the development of the trout's egg will be found in Zeitschrift f. wiss. Zool., Vol. 22, Part IV., Plates 32 and 33, and Vol. 23, Part I., plates, 1, 2, 3, and 4, in papers by Professor Oellacher of Innsbruck.

3839a. Collection of **Preparations** for the **Study** of the **Embryology** of the **Sterlet** (*Acipenser ruthenus*), from the segmentation of the egg to the one year old fish.

Ph. Owsiannikoff, University of St. Petersburg.

The first artificial fecundation of the eggs of this fish was made by M. Ph. Owsiannikoff, in the year 1869, at Simbirsk on the Wolga, and in the same year a small quantity was brought by him to St. Petersburg. The exhibited embryos presented have grown up in an aquarium in the study room of M. Owsiannikoff, who wishes to present them to the South Kensington Museum.

3839b. Preparations on the **Embryology** of the **Sterlet** (*Acipenser ruthenus*).

Ph. Owsiannikoff, University of St. Petersburg.

The time is fixed approximately, as at an early stage temperature and quantity of food have a great influence on the development. No. 1. First day, the hole of Rusconii forms the half of the egg. No. 2. Second day, morning, the hole of Rusconii is smaller. No. 3. Second day, evening, the hole of Rusconii is very small. No. 4. Fourth day, the hole of Rusconii has disappeared. No. 5. Fifth day. No. 6. Sixth day. No. 7. Seventh day. No. 8. The third and fifth days after their coming out from the egg. No. 9. About a week after their coming out. Nos. 10, 11, 12, 13. From two to four weeks. No. 14. About six weeks; bastard of an Acipenser Güldenstaedtii (soft roe), and of an Acipenser ruthenus (hard roe). No. 15. About two months. No. 16. About a year; reared in an aquarium. If there is plenty of food the fish can attain about double this size in the same period.

3933b. Collection of Preparations on the Embryology of the Sterlet ((*Acipenser ruthenus*).

Ph. Owsiannikoff, University of St. Petersburg.

Most of the preparations represent tranverse sections of the eggs or the embryos, hardened in chromic acid, and partly coloured with carmine.

1. Ripe but not fecundated egg.
2. Embryo, taken from the egg thirty-seven hours after fecundation.
3. Embryo, about forty hours after fecundation.
4. Transverse section of an embryo of thirty-seven hours.
5. Transverse section of an embryo of forty-eight hours.
6. Section of the brain and the eye-vesicle of an older embryo.
7. The three embryonal plates.
8. Section through the nerve-ganglion; the rudimentary gills are to be seen.
9. This section represents the cells that form the medulla spinalis, chorda dorsalis, and other parts.
10. Section through the head of a sterlet just coming out from the egg-shell.
11. Sterlet about three days after coming out.
12. Sterlet about a week.
13. Some longitudinal sections of a one week's sterlet. We see the eyes, the heart, the intestinal canal, particular nervous organs of the surface of the head.
14. The segment.

15, 16. The spinal furrow and the first plates.

17. The closing of the spinal furrow; the plates are not completely formed.
18. Longitudinal section through an embryo in the egg-shell. The interesting feature of this preparation is the closing of the intestinal canal.
19. Transverse section of an embryo, formation of muscles, construction of the spinal chord, wolffian body, &c.
20. Preparation of a coregonus, showing the central nervous system.
21. Section of an egg of petronzyon fluviatiles, showing the formation of the intestinal canal.

3933a. Collection of Preparations of the Nervous System of Molluscs.

Ph. Owsiannikoff, University of St. Petersburg.

1–3. Whole nerve-ganglion and two sections, from a thetis.

4. Aeolis.

5, 6. Gastropteron.

7. Bulla, with eyes.
8. Umbrella.
9. Pleurobranchus.
10. Pleurobranchus, section of a nerve-ganglion.
11. Aplysia.
12. Lobulus electricus (Rajae). The section is made of a brain preserved for three years in spirit, the cells and fibres are still seen very well.
13. Dentalium.

3933c. Eight Drawings illustrative of the **minute structure** and **reproductive process of the Mushroom Tribe.**

W. G. Smith.

These drawings show the reproductive process, the minute structure, and every individual cell of *Coprinus radiatus*, one of the smallest members of the mushroom tribe. The fungus, natural size, is shown growing upon fragments of straw or dung on drawings Nos. 1, 2, 7, and 8. The enlarged details are magnified from 25 to 3,000 diameters by the aid of the camera-lucida attached to the eye-piece of the microscope. Height of the full grown fungus $\frac{3}{8}$ of an inch. Number of cells entering into the composition of one fungus, 25,760,000. Weight of one fungus, $\frac{1}{150}$ of a grain.

3933d. Four Glass Cases, containing a series of **dissections of Insects** of various orders. *Professor Westwood.*

3933e. Glass Case, containing 39 microscopic slides and dissections of insects. *Professor Westwood.*

3840. Original Cast of the trunk of a boy, the thorax opened to show the natural position of the heart after removing the lungs. *Steger, Anatomical Institute, University of Leipzig.*

3841. Cast, with the **Abdominal Cavity** opened to show the natural form and position of the stomach, liver, and kidneys, &c. *Steger, Anatomical Institute, University of Leipzig.*

3842. Several Small Original Casts.
Steger, Anatomical Institute, University of Leipzig.

3843. Histological Photographs.
Steger, Anatomical Institute, University of Leipzig.

3844. Photographs to illustrate the **Changes** during **Development** of the chick.
Steger, Anatomical Institute, University of Leipzig.

3845. 25 Photographs on Glass, for the magic lantern, for instruction in physiology (anatomy, physiology, biology, and development). *Dr. S. Th. Stein, Frankfort on the Maine.*

These slides have been photographed from nature.

3846. Three Large Diagrams.
Dr. S. Th. Stein, Frankfort on the Maine.

These contain—

1. 35 physiological photographs. (The whole taken from nature.)
2. The application of photography to physiology and medicine.
3. Thermophotography.

3847. Diagrams, for botanical teaching, by L. Kny. 1–20. *Prof. Kny, Berlin.*

These diagrams are published by Wigand, Hempel, & Co., Berlin.

3849. Model of the Mechanism of the Accommodation of the Eye. *Prof. Beetz, Munich.*

This model is made by Tauber of Leipzig from a design of Dr. Beetz, and is explained by a drawing and description which accompany the apparatus.

3850. Three Wall Charts, with representations of **the Technical Geography of Plants.**

Prof. Jessen, Eldena, in Pomerania.

3851. Apparatus for representing the mechanical principle of the **Circulation** of **Sap** in **Cells.** Rough model.

Prof. Jessen, Eldena, in Pomerania.

3852. Plan of the **Institute of Vegetable Physiology of the University of Breslau,** with an account of its arrangements for instruction in the biology of plants.

Prof. Dr. F. Cohn, Institute of Vegetable Physiology, University of Breslau.

The Institute of Vegetable Physiology in the University of Breslau was founded in the year 1866, and was intended (*a*) for experiments for the elucidation of the biology of plants, also for preparing all kinds of demonstrations for the lectures of its director, Professor Ferdinand Cohn, and to found for this purpose collections of apparatus, models, normal and pathological plant forms, herbaria, &c.; (*b*) to make the students, by means of courses of instruction on histology, familiar with the use of the microscope for phytobiological researches, and to afford them, by means of a collection of microscopical preparations, rich material for observation; (*c*) to secure for original researches on the biology of plants the necessary rooms, instruments, and other assistance, as well as direction, and to publish the same as far as possible in the scientific publication of the institute, "Beiträge zur Biologie der Pflanzen; Breslau, Verlag von Max Müller."

3853. Six Models, prepared by A. Lohmeyer, and presented to the collection of botanical models in the Phytophysiological Institute.

Vaucheria sessilis, development of the Sexual Organs.

Vaucheria sessilis, development of the Zoospores.

Eurotium aspergillus, development.

Models of Antherozoids.

Models of Zoospores.

Cypripedium Calceolus, model of the flower.

Prof. Dr. F. Cohn, Institute of Vegetable Physiology, University of Breslau.

M. A. Lohmeyer prepared, during the years 1862-67, by the suggestion and under the direction of Professor F. Cohn, an extensive collection of botanical models comprising more than 350 specimens, the first and most complete of its kind which illustrates the structure of flowers and fruits of the phanerogamic families of plants, with especial attention to officinal plants and the development of the cryptogams. Out of this sprang the collection of botanical models made for sale by Brendel, and exhibited in his name.

3860. Glazed Frame, with movable back for demonstrating biological preparations and drawings. The development of rusts. (Æcidium Berberidis, Puccinia graminis, Uredo linearis.)

Dr. F. Cohn, Institute of Vegetable Physiology, University of Breslau.

For lecture-demonstrations of herbarium specimens of morphological preparations, and collections of microscopical drawings and natural objects which elucidate the diseases, &c. of plants, the glass frames with movable back, which are in common use at the Institute of Vegetable Physiology, are exceedingly well adapted.

3861. 12 Botanical Models of Cultivated Plants.
Robert Brendel, Berlin.

3862. 5 Botanical Models of Fruit Trees.
Robert Brendel, Berlin.

3863. 5 Botanical Models of Forest Trees.
Robert Brendel, Berlin.

3864. 45 Models of Flowers. *Robert Brendel, Berlin.*

These 67 botanical models were constructed to illustrate the structure of flowers, of cultivated and wild plants, and the natural orders. They include—

1. Cultivated mono- and dicotyledonous plants, *e.g.*, families of the Cruciferæ, Lineæ, Leguminosæ, and Gramineæ.
2. Fruit trees of the families Ampelidæ, Pomaceæ, Rosaceæ, Ribesiaceæ, and Amygdaleæ.
3. Forest trees, from the families of the Coniferæ (Abietineæ Taxineæ), Salicineæ, and Cupuliferæ.
4. Models of the inflorescence of the principal German orders, including Ferns and Equisetaceæ.

The botanical models (which are durably made of gutta-percha, papier mâché, &c., held together with cane, wires, &c., and painted true to nature in oil colours) are intended to illustrate lectures on the artificial and natural orders, regardless of the seasons, and in systematic order. As the models are made on a more or less enlarged scale, they facilitate the recognition of all the fine and even smallest organs, and the comprehension of the distinguishing characteristics of the structure of flowers by comparison with living plants; besides, many can be taken to pieces, and are represented in sections. The models, as a means of botanical teaching, were first prepared at the suggestion and under the guidance and direction of Professor F. Cohn, by M. Lohmeyer, who died in 1872, and presented his collection of over 300 models to the Institute of Vegetable Physiology in the University of Breslau. The models supplied by the exhibitor are now prepared directly from nature.

3864a. Six Photographs (in frame with glass)**, for demonstrating the consequences of exterior injuries to trees,** illustrative of the publication and atlas, "Über die Folgen äuperer Verletzungen der Bäume."

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864b. Seven Photographs (in frame with glass)**, for demonstrating the effect of frost on trees.**

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864c. Four Photographs (in frame with glass)**, for demonstrating the deformed growth of trees.**

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864d. Three Photographs for demonstrating the formation of the veins and branches of trees, according to the publication "Über Maserbildung."

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864e. Three Photographs and Sections of Wood (in frame with glass). Originals, illustrative of the publication, "Über Zeichen und Schriften der Bäume."

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864f. Scene from the Primeval Forests of the Bohemian Mountains.

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864g. Photograph of the coal profile erected in the Botanical Garden.

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864h. Section of Wood for demonstrating the process of grafting and improved growth, according to the publication, "Über das Veredeln der Obstbäume."

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864i. Zinc Model, representing the **Rafflesia Arnoldi.**

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864j. Atlas, with Photographs and Inscription, Austellung des Botanischen Gartens."

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3864k. Göppert on Medicinal Plants, Botanical Museums, Formation of Veins, Inscriptions in Trees, Effects of Internal Injury, Process of Grafting.

Royal Botanical Garden and Museum of the University of Breslau, Prof. Dr. H. R. Göppert, Director.

3865. Six Models of Radiolaria, in papier mâché.

V. Fric, Prague.

3866. Twelve Types of Foraminifera, recent and fossil, representing the system of Carpenter, with a drawing of each on a large scale. *V. Fric, Prague.*

3867. Mòdel of a Human Leg, with sections at intervals; for use in giving anatomical and surgical instruction.

Dr. Pansch, Kiel.

This model has been moulded by the exhibitor accurately from nature, by 13 sections in successive planes through a firmly frozen leg. The advantages of such models for teaching, in lieu of the imperfect representations which have hitherto been used, are self-evident.

Models of other parts of the body similar to this have already been taken in hand by the exhibitor.

3868. Section of Head.
Rammé and Sodtmann, Hamburg.

By these anatomical models in papier mâché, the exhibitors intend to give a general insight into the structure of the human body to scholars and intelligent people. The aim of the exhibitors has been to combine accuracy with the greatest possible cheapness and durability.

Some of the models are taken from drawings by Dr. Simon, and some from those by Dr. Dehn.

3869. Head, with Muscles.
Rammé and Sodtmann, Hamburg.

3870. Model of the Ear enlarged, without muscles.
Rammé and Sodtmann, Hamburg.

3871. Eye enlarged. Perpendicular section.
Rammé and Sodtmann, Hamburg.

3872. Larynx, &c., natural size.
Rammé and Sodtmann, Hamburg.

3873. Lung. Perpendicular section.
Rammé and Sodtmann, Hamburg.

3874. Larynx and Lungs, in separable parts.
Rammé and Sodtmann, Hamburg.

3875. Model of Thorax, in separable parts.
Rammé and Sodtmann, Hamburg.

3876. Digestive Apparatus.
Rammé and Sodtmann, Hamburg.

3877. Perpendicular Section of Skin.
Rammé and Sodtmann, Hamburg.

3878. Biological Preparations for teaching zoology :—

1. Sphegidæ. Family of the carnivorous wasps, showing the rapacious manner of life and dwelling, with their victims.
2. Megachile betulina, a bee which cuts off a portion of birch leaf, showing its dwelling, with the piece of the leaf bitten off.
3. Bombus lapidarius, the mason bee, with construction of comb.
4. Myrmecoleon formicarius, the antlion, its funnel shaped-pit, larvæ, cocoons, &c.
5. Locusta viridissima, deposition of eggs and development.
6. Insects in amber, and their origin.

Prof. Dr. H. Landois, Münster, Westphalia.

The preparations which have been sent are intended as specimens for zoological instruction in the higher class educational establishments. They can be continually renewed by any teacher, and are not liable to destruction, and will raise the standard of the objects concerned in teaching. They attracted the notice of the judges in the Vienna Exhibition, and gained a medal as a mark of merit.

These and the following preparations were constructed for the exhibitor by Rudolph Roch, of Münster, manufacturer of anatomical preparations.

3878a. Two Preparations. Heads of children.

Ph. Owsiannikoff, University of St. Petersburg.

These preparations are taken from the Anatomical Museum of the Academy of Science at St. Petersburg; they were bought by the Emperor Peter the Great, in the year 1717, from the eminent anatomist of Holland, Ruysch (1638–1731), with his whole excellent collection.

The lessons of anatomy, the nervous system especially, must be demonstrated by preparations. Most of these preparations in spirit cannot be long preserved. The preparations of Ruysch, though very old, are extremely well preserved. The collection of preparations by Ruysch at the Anatomical Museum of the Academy of Science at Petersburg is unique in Europe.

3879. Horizontal Section of the Eye-ball through its meridian in a child six months old.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3880. Horizontal Section of the Tympanic Cavity and the cochlea of a child 10 months old.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3881. Frontal Section of the Head of a Child six months old through the cavities of the pharynx and mouth.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3882. Median Sagittal Section through the Head of a Child four months old.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3883. Lateral Sagittal Section through the Head of a Child four months old.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3884. Horizontal Section through the Neck of a Child six months old.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3885. Horizontal Section through the Neck of the same Child somewhat deeper.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3886. Three Longitudinal Sections through the Heart of a Child 32 days old.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3887. Two Sections through the Larynx of a Child six months old.

Anatomical Institute, Erlangen (Prof. Dr. B. Gerlach).

3888. Two Sections, one longitudinal, one transverse, **through the Testicle of an Adult.**
Anatomical Institute, Erlangen (*Prof. Dr. B. Gerlach*).

3889. Median Longitudinal Section through the Uterus of a virgin 20 years old.
Anatomical Institute, Erlangen (*Prof. Dr. B. Gerlach*).

3890. Cross Section through the Arm of a Child six months old, in the upper third.
Anatomical Institute, Erlangen (*Prof. Dr. B. Gerlach*).

3891. Cross Section of the Fore-arm of a Child six months old, in the upper third.
Anatomical Institute, Erlangen (*Prof. Dr. B. Gerlach*).

3892. Cross Section of the Fore-arm of a Child six months old, in the lower third (a glycerine preparation).
Anatomical Institute, Erlangen (*Prof. Dr. B. Gerlach*).

All these sections were prepared by the exhibitor for the purpose of demonstrating to a large audience, by means of the magic lantern (sciopticon), certain anatomical features, especially with regard to their topographical relations.

3893. Models of the Blood Corpuscles, for illustrating their form and size. (Magnified 5,000 times.)
Prof. Dr. H. Welcker, Halle an der Saale.

3894. Model of the Bones of the Arm of Man, for demonstrating supination and pronation. Also an osteological preparation to which the bone of the fore-arm is attached by a steel wire. *Prof. Dr. H. Welcker, Halle an der Saale.*

3895. Orchitis interstitialis.
Pietro Toninetti Pathological Institute, Berlin (*Director, Prof. Dr. Virchow*).

By means of this fluid, discovered by the exhibitor, the objects were kept perfectly fresh, and when prepared in the dry way by the exhibitor retained their fresh appearance.

3896. Normal Heart.
Pietro Toninetti Pathological Institute, Berlin (*Director, Prof. Dr. Virchow*).

3897. Lipoma subcutaneum.
Pietro Toninetti Pathological Institute, Berlin (*Director, Prof. Dr. Virchow*).

3898. Glioma cerebri.
Pietro Toninetti Pathological Institute, Berlin (*Director, Prof. Dr. Virchow*).

3899. Slaty discolouration of the mucous membrane of the large intestine.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3900. Two Kidneys.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3901. Two Normal Brains.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3902. Bullock's Heart and Lungs.

Pietro Toninetti Pathological Institute, Berlin (Director, Prof. Dr. Virchow).

3903. Histological Preparations for Teaching.

C. Rodig, Hamburg.

I. Collection of 150 drug preparations, in accordance with the pharmaceutical atlas of Professor Berg, adapted for pharmaceutical instruction.
II. Sixty anatomical plant preparations for teaching botany.
III. Algæ, fungi, and mosses.
IV. Cereals in sections for agricultural teaching.

3904. Sketch of an apparatus for investigating the **Influence of Temperature** on the life of **Plants** and **Animals.**

Dr. W. Velten, Physiologist, I. R. Station for Experiments relating to Forests, Vienna.

The apparatus consists of a box of zinc, with double partitions, the upper and sides perpendicular thereto being replaced by parallel glass plates. The space between the partitions must be filled with fluids, while that in the centre is destined for the objects to be experimented on. The whole is surrounded by a wooden cover suited to receive a refrigerator. The box is heated from below, and the temperature retained constant by means of a thermo-regulator brought into connexion with the apparatus. At the sides are openings into which the hands should be placed, when encased in india-rubber gloves only, in order to work without great change of temperature in the apparatus itself. By means of the same apparatus the influence of various coloured light can be determined as well as that of gas, &c. at different degrees of temperature.

3904a. Skeleton of a Dog, disarticulated and mounted in such a manner that every bone can be separately removed for examination. *Prof. Huxley, F.R.S.*

3904b. Typical Parts of the Skeletons of a Cat, a Duck, and a Codfish, disarticulated and mounted, to show the chief modifications of the vertebrate endoskeleton.

Prof. Huxley, F.R.S.

3904c. Series of Fifteen Dissections, illustrating the anatomy of the edible **Frog** (Rana esculenta).
Prof. Huxley, F.R.S.

3904d. Series of Sixteen Diagrams, illustrating the anatomy of the **Frog.** *Prof. Huxley, F.R.S.*

3904e. Exoskeleton of the Common Lobster, disarticulated and mounted. *Prof. Huxley, F.R.S.*

3905. Botanical Class Diagrams, used by the Professor of Botany, Royal College of Science. Diagrams of Closterium and Euastrum; also of Cycas circinalis, illustrating drawings used in the botanical class in the Royal College of Science.
W. R. M'Nab, M.D.

3906. Models of Monocotyledonous Embryos (8), prepared by Dr. Ziegler, of Freiburg, in Breisgau, part of a set of wax models used in the botanical class in the Royal College of Science. *W. R. M'Nab, M.D.*

3907. Models of the flowers of Monocotyledonous and Dicotyledonous plants; part of a set of models prepared by Robert Brendel, in Breslau, used in the botanical class in the Royal College of Science. *W. R. M'Nab, M.D.*

3908. Diagram of the Myxastrum Radians, a non-nucleated Protozoon. *Prof. A. Leith Adams, F.R.S.*

3909. Diagrams of the Eucecryphalus Schulzei and Heliosphera Inermis. *Prof. A. Leith Adams, F.R.S.*

The above are two forms of Radiolaria, showing their siliceous basket-like skeletons, and the cellform bodies of a bright yellow colour, containing starch. The nuclei and pseudopodia with granules are also represented.

3910. Case of Specimens, illustrating the **Domination of one Plant over another** in the mixed herbage of grass land, under the influence of different manures, each applied year after year on the same plot. *John Bennet Lawes.*

The experiments were made in Mr. Lawes' park, at Rothamsted, near St. Albans, commencing in 1856, at which time the character of the herbage was apparently pretty uniform over all the plots, and there were 50 species or more growing together. There are about 20 experimental plots, from a quarter to half an acre each; two being left continuously without manure, and each of the others receiving its own special manure year after year. Under this varied treatment, changes in the *flora*, so to speak, became apparent even in the first years of the experiments; and three times since heir commencement, at intervals of five years, namely, in 1862, 1867, and 1872, a carefully averaged sample of the produce of each plot has been taken, and submitted to careful botanical separation, and the per-centage by weight of each species in the mixed herbage determined. Partial separations have also been made in other years. The specimens exhibited in the case show the botanical composition of the herbage on 12 selected plots, in the 17th season of the experiments, 1872; and the quantities represent the relative proportion by weight in which each species was found in the mixed produce of the plots.

The mean produce of hay per acre per annum has ranged on the different plots from about 23 cwts. without manure, to about 64 cwts. on the plot the most heavily manured.

The number of species found has generally been about 50 on the unmanured plots, and has been reduced to an average of only 20, and has sometimes been less, on the most heavily manured plots.

Species belonging to the order *Graminaceæ* have, on the average, contributed about 67 per cent. of the weight of the mixed herbage grown without manure, about 65 per cent. of that grown by purely mineral manures (that is, without nitrogen), and about 94 per cent. of that grown by the same mineral manures with a large quantity of ammonia-salts in addition.

Species of the order *Leguminosæ* have, on the average, contributed about 8 per cent. of the produce without manure, about 20 per cent. of that with purely mineral manures, and less than 0·01 per cent. of that with the mixture of the mineral manures and a large quantity of ammonia-salts.

Species belonging to various other orders have, on the average, contributed about 25 per cent. of the produce without manure, about 15 per cent. of that with purely mineral manures, and only about 6 per cent. of that with the mixture of the mineral manures and a large amount of ammonia-salts.

Not only the amount of produce, but the number and description of species developed, have varied very greatly between the extremes here quoted, according to the particular character or combination of manure employed, as is strikingly illustrated by the arrangement of the specimens in the case.

3910a. Photographs under glass, for demonstrating the consequences of exterior damages to trees, the influence of cold on trees, and modes of protection of trees.

Royal Botanical Garden and Museum of the University at Breslau (Prof. Dr. H. R. Göppert).

3911. E. J. Spitta's working Model of the larynx.

T. Hawksley.

3912. 106 Original Water-Colour Drawings, by Wolf, illustrating the new and rare animals exhibited in the Society's Gardens. *The Zoological Society of London.*

(Uprights.)

1. Orang-Outang - - - *Simia satyrus.*
2. Chimpanzee - - - *Troglodytes niger.*
3. Hoolock Gibbon - - - *Hylobates hoolock.*

(Longs.)

4. Ashy-black Ape - - - *Macacus ocreatus.*
5. Black-fronted Lemur - - *Lemur nigrifrons.*
6. Lioness and Young - - - *Felis leo.*
7. Painted Ocelot - - - *Felis picta.*
8. Ocelot - - - - *Felis pardalis.*
9. Ocelot - - - - *Felis pardalis.*
10. Egyptian Cat - - - *Felis chaus.*

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11. Leopards	*Felis leopardis.*
12. Viverrine Cat	*Felis viverrina.*
13. Canadian Lynx	*Felis canadensis.*
14. Serval	*Felis serval.*
15. Caracal	*Felis caracal.*
16. Caracal	*Felis caracal.*
17. Eyra	*Felis eyra.*
18. Cheetah	*Felis jubata.*
19. Indian Civet	*Viverricula indica.*
20. Ratels	*Mellivora capensis & M. indica.*
21. American Skunk	*Mephitis mephitica.*
22. Fennec Fox	*Canis cerdo.*
23. Azara's Fox	*Canis azaræ.*
24. Bassaris	*Bassaris astuta.*
25. African Elephants	*Elephas africanus.*
26. Walrus	*Trichechus rosmarus.*
27. Southern Sea-lion	*Otaria jubata.*
28. African Rhinoceros	*Rhinoceros bicornis.*
29. Andaman Pig	*Sus andamanensis.*
30. Red Potamochere	*Potamochærus africanus.*
31. Bosch-Vark	*Potamochærus penicillatus.*
32. Collared Peccary	*Dicotyles torquatus.*
33. Hippopotamus	*Hippopotamus amphibius.*
34. Hippopotamus	*Hippopotamus amphibius.*
35. Panjaub Sheep	*Ovis cycloceros.*
36. Thar Goat	*Capra iemlaica.*
37. Persian Gazelle	*Gazella subgutturosa.*
38. Eland (young)	*Oreas canna.*
39. Chinese Tailed Deer	*Cervus davidianus.*
40. Mantchurian Deer	*Cervus mantchuricus.*
41. Formosan Deer	*Cervus pseudaxis.*
42. White-tailed Deer	*Cervus leucurus.*
43. Japanese Deer	*Cervus sika.*
44. Rusa Deer	*Cervus rusa.*
45. Swinhoe's Deer	*Cervus swinhoii.*
46. Persian Deer	*Cervus maral.*
47. Pudu Deer	*Cervus pudu.*
48. Large-eared Brocket	*Cervus auritus.*
49. Alpacas	*Auchenia pacos.*
50. Great Ant-eater	*Myrmecophaga jubata.*
51. Great Ant-eater	*Myrmecophaga jubata.*
52. Two-toed Sloth	*Cholopus didactylus.*
53. Thylasine	*Thylacinus cynocephalus.*
54. Broad-fronted Wombat	*Phascolomys latifrons.*
55. Common Wombat	*Phascolomys wombat.*
56. Mantell's Apteryx	*Apteryx mantelli.*
57. Mooruk	*Casuarius bennetti.*
58. Rhea (young)	*Rhea americana.*
59. Painted Spur-fowl	*Galloperdix lunualso.*
60. Caspian Snow Partridge	*Tetraogallus caspius.*
61. Sœmmerring's Pheasant	*Phasianus sœmmerringi.*
62. Ring-necked Pheasant	*Phasianus torquatus.*
63. Japanese Pheasant	*Phasianus versicolor.*
64. Horned Tragopan	*Ceriornis satyra.*
65. Rufous-tailed Pheasant	*Euplocamus erythrophthalmus.*
66. Vieillot's Fire-back	*Euplocamus vielloti.*

67. Swinhoe's Fire-back - - *Euplocamus swinhoii.*
68. Horsfield's Kaleege - - - *Euplocamus horsfieldi.*
69. Siamese Pheasant - - - *Euplocamus prælatus.*
70. Lineated Pheasant - - - *Euplocamus lineatus.*
71. Weka Rails - - - - *Ocydromus australis.*
72. Brush Turkey - - - *Talegalla lathami.*
73. Black-necked Swan - - - *Cygnus nigricollis.*
74. White-winged Casarca - - *Casarca leucoptera.*
75. Upland Goose - - - *Chloëphaga magellanica.*
76. Ashy-headed Goose - - - *Chloëphaga poliocephala.*
77. Indian Tantalus - - - *Tantalus leucocephalus.*
78. African Tantalus - - - *Tantalus ibis.*
79. Shoebill - - - - *Balæniceps rex.*
80. Egrets - - - - *Ardea candidissima & A. garzetta.*
81. Mantchurian Crane - - - *Grus montignesia.*
82. Kagu - - - - - *Rhinochetus jubatus.*
83. Angola Vulture - - - *Gypohierax angolensis.*
84. Bataleur Eagle - - - *Helotarsus ecaudatus.*
85. Schlegel's Clotho - - - *Clotho rhinoceros.*
86. Clotho - - - - *Clotho nasicornis.*

(Uprights.)

87. Stanger's Monkey - - - *Cercopithecus stangeri.*
88. Ocelot - - - - *Felis pardalis.*
89. Ocelot - - - - *Felis pardalis.*
90. Clouded Tiger - - - *Felis macrocelis.*
91. Norwegian Lynx - - - *Felis lynx.*
92. Binturong - - - - *Arctictis binturong.*
93. Syrian Bear - - - - *Ursus syriacus.*
94. Aoudad - - - - *Ovis tragelaphus.*
95. Markhoor - - - - *Capra megaceros.*
96. Bar-tailed Pheasant - - - *Phasianus reevesi.*
97. Australian Mycteria - - *Mycteria australis.*
98. Saddle-billed Stork - - *Mycteria senegalensis.*
99. Rhinoceros Hornbill - - *Buceros rhinoceros.*
100. Concave-casqued Hornbill - - *Buceros bicornis.*
101. Iceland Falcon - - - *Falco islandicus.*
102. Saker Falcon - - - *Falco sacer.*
103. Lanner Falcon - - - *Falco lanarius.*
104. Greenland Falcon - - - *Falco grœnlandicus.*
105. Spotted Eagle - - - *Aquila nævia.*
106. Green Boa - - - - *Xiphosoma caninum.*

3913. Skeleton of a Man, mounted (after Beauchène).
Tramond, Paris.

3914. Skeleton of a Man, for practising dislocations.
Tramond, Paris.

3915. Human Head, with worn jaw (after Beauchène).
Tramond, Paris.

3916. Child's Head, showing first and second dentitions.
Tramond, Paris.

3917. Head of Python (after Beauchène). *Tramond, Paris.*

3918. Head of Tortoise (after Beauchène).
Tramond, Paris.

3919. Skeleton of Young Chimpanzee. *Tramond, Paris.*

3920. Skeleton of Gibbon. *Tramond, Paris.*

3921. Skeleton of Crane. *Tramond, Paris.*

3922. Skeleton of Adult Beaver. *Tramond, Paris.*

3923. Model, showing **Muscles** and **Nerves.**
Tramond, Paris.

3924. Entire Head, showing **Nerves, Vessels, Sinus, &c.** *Tramond, Paris.*

3925. Anatomy of the Eye, in 13 pieces. *Tramond, Paris.*

3926. Two Fœtuses. *Tramond, Paris.*

3927. Complete Circulation in the Fœtus.
Tramond, Paris.

3928. Skeleton of Rattlesnake. *Tramond, Paris.*

3929. Lymphatic Vessels, natural size (vulva).
Tramond, Paris.

3930. Lymphatic Vessels, natural size (tongue).
Tramond, Paris.

3931. Lymphatic Vessels, natural size (leg and foot of a child). *Tramond, Paris.*

3932. Lymphatic Vessels, natural size (portion of the large intestine). *Tramond, Paris.*

3933. Lymphatic Vessels, natural size (half the head of a fœtus). *Tramond, Paris*

XII.—MISCELLANEOUS APPARATUS.

3934. Heliopictor, an automatic photographic apparatus for producing zoological and physiological photographs, with all necessary apparatus, in a box.
Dr. S. Th. Stein, Frankfort on the Maine.

See Vogel's "Photogr. Mittheilungen," 1873.

3934a. Polarising Apparatus of **Hoppe-Seyler.**
F. Schmidt and Haensch, Berlin.

This apparatus is especially suited to the wants of medical men, for estimating sugar or albumen in urine. It is distinguished from the apparatus of Soleil, in giving the quantity of sugar in per-centages and tenths, by direct inspection of scale.

3935. Germinating Apparatus, for the simultaneous germination of a large number of seeds, or for the cultivation of microscopical organisms at a constant degree of temperature and moisture. (Exhibitor's construction.)

Prof. Dr. F. Cohn, Institute of Vegetable Physiology, University of Breslau.

This apparatus satisfactorily replaces the germinating apparatus of Nobbe. The seeds are soaked for 24 hours in water, then 200 are placed in each earthenware dish and covered over. The enclosed tin dishes are then filled with water, which keeps in the porous clay dishes the moisture requisite for the development of the seeds. The space between the double walls of the chamber is now three-quarters filled with water (the height of the water can be seen by the glass gauge), and a small gas flame, governed by a Bunsen's regulator and placed underneath the germinating chamber, keeps the temperature very constant. This apparatus is used for the examination of the germinating power of agricultural seeds, which takes place at the seed control station (Samen-Controll Station) connected with the Institute of Vegetable Physiology. Similar apparatus of different sizes are used in this station continually for the culture of plants, especially microscopical growths, at a constant temperature. They were employed especially by Prof. Cohn in his researches on Bacteria.

3935a. Cultivation Apparatus, with admission of air.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Prof. Edwin Klebs).

The circular vessel is filled to half of its height with a mixture of water, glycerine, and sulphuric acid (or sulphate of copper), and the glass globe dipped into the cohesive fluid. The little round vessel contains the substance for cultivation, mostly gelatine. The open neck of the globe is wrapped round with wadding, and on this is placed the small, broad-brimmed, thick-shelled globe. The air in the globe, as well as the substrata of cultivation, are purified by the infusion of a powerful jet of steam. The introduction of germs, as well as the removal of samples, is effected under a "spray" of permanganate of potash.

Among 70 preparations by this method, only a very few showed a spontaneous development of fungi, whereas "Hyphomycetes" and "Schistomycetes" thrive excellently in them after implantation of their germs.

3935b. Apparatus for the cultivation of fungi.

The Imperial and Royal Pathological and Anatomical Institute of the University of Prague (Director, Prof. Edwin Klebs).

Two glass chambers for microscopical observation :—

a. Filled nearly full with isinglass gelatine. Implantation of "Microsporon septicum" of the year 1872. Ring-shaped progressive development of the "Schistomycetes" round a capillary tube, which contained the germs.

b. Filled half to its height with isinglass gelatine. The vegetation of the "Microsporon sept." ceased early, and the gelatine has to some extent become liquid.

"Hyphomycetes" did not make any appearance, although they thrive in such chambers. Without importation of germs, these chambers, with their contents, will remain free from any formation of fungi.

3936. Apparatus for demonstrating Knight's Experiment on the influence of gravity on the direction of the growth of roots and stems of budding plants. (Exhibitor's construction.)

Prof. Dr. F. Cohn, Institute of Vegetable Physiology, University of Breslau.

Some seeds (by preference Pisum sativum and Zea maize) are soaked for 24 hours in water, and then attached by long needles, which must not pass through the radicle or the plumula, but only through the cotyledons or the endosperm, radially to the circumference of a disc of cork. The apparatus is set in action by connecting the caoutchouc tube of the cover with the water supply or a water reservoir. By regulating the strength of the stream of water the rate of the waterwheel can be increased or diminished. The splashing of the water furnishes sufficient moisture for the germination of the seeds, from which all the roots are developed centrifugally, whilst the stems grow in a centripetal direction. An apparatus similar to this was employed by Prof. Ciesieboki in the Institute of Vegetable Physiology for his researches on the bending downwards of the root (see Cohn's Beiträge zur Biologie der Pflanzen, Vol. I., part 2). The observations can be made through the glass window, which is, however, generally closed by a shutter in order to keep out the light.

3937. Apparatus for Observing the Velocity of Growth in Plants (constructed by Prof. Reinke).

Institute of Vegetable Physiology of Göttingen (Director, Prof. Grisebach).

3938. Apparatus for Registering the Growth of Plants.

E. Stöhrer, Leipzig.

The principle of the apparatus is, that the making and breaking of a galvanic current sets in motion a lever which works between the poles of an electro-magnet, and carries a writing point at its extremity. This pen is pressed against and marks, on a drum of paper (which is turned round once in 24 hours by clockwork) a circular line. The portion of the plant under observation is brought into connexion with the pen by means of a delicate system of levers. A growth of even ½–1 millimetre of the plant will cause the making and breaking of the current, the vibrator will thus move, and on the circular line will be recorded curved tracings which indicate the growth of the plant.

The second registering apparatus of which only a photograph is sent is intended for researches on the turning down and pressure of the root. A sheet of paper divided into minutes and hours is applied to a large brass cylinder, which is turned round on its axis daily or hourly by clockwork. The oscillations of the column of water are written on the paper by means of a cork float bearing a glass pen filled with anilin solution.

3939. Apparatus for Researches on the Physiological exchange of Material in the Sheep.

Prof. Henneberg, Agricultural Research Office, Station of the Hanoverian Agricultural Society, Göttingen.

It is necessary for researches on the total exchange of material in an animal to collect completely and separately the fæces and the urine. The stall exhibited serves to illustrate the method in which the experiment was carried out at the Research Station at Göttingen-Weende, when a sheep formed the subject of investigation. The single pen stall was erected in the chamber of Pettenkofer's respiration apparatus on those days when, in addition, the products of respiration were determined.

See Neue Beiträge zur Begründung einer rationellen Fütterung der Wiederkäuer, edited by Henneberg, Göttingen, 1870–71.

3940. Mercurial Air Pump, for the analysis of blood-gases.
Ch. F. Geissler & Son, Berlin.

The taps of the air pumps and other apparatus must be turned gently after they have been smeared slightly with lard until they appear transparent and clear.

3941. Sample Collection of Sections of Wood.
Dr. H. Nördlinger, Hohenheim, Württemberg.

The volume, which is the seventh published, contains, as well as the six preceding, 100 species of woods botanically determined. Although following as far as possible the Linnæan nomenclature, it introduces, however, about 50 new genera. It gives also an extraordinary variety of the inner structures of trees. There are specimens amongst them of the Suæda of the Mediterranean, and Atherstonia of the Cape, which can, on account of their abnormal structure, be only classified with difficulty.

Especially interesting is the comparison of the species of different genera of woods coming from different climates.

3942. Lucæ's Drawing Apparatus, modified by Spengel.
A. Wichmann, Hamburg.

3943. Orthoscope. *A. Wichmann, Hamburg.*

3944. Two Large Sachs' Vegetation Flasks, for coloured light, 500 mm. high, and 250 mm. across.
Warmbrunn, Quilitz, & Co., Berlin.

3945. Two Smallar Flasks, entirely of glass.
Warmbrunn, Quilitz, & Co., Berlin.

3946. Kronecker's Warm Chamber for Digestion.
Warmbrunn, Quilitz, & Co., Berlin.

3947. Ludwig's Strom ühr or Hæmodromometer.
T. Hawksley.

3949. Set of Physiological Operating Instruments.
T. Hawksley.

3949a. Table, with—

(*a.*) Fifteen pieces of the original burners which Middeldorpf, the discoverer of galvano-caustic, employed.

(*b.*) Collection of nine different uterus cauterizers. Wen constrictor. Bow cutter, with five adaptable tubes. Appliance for cauterizing the almond glands. Sliding corrector.

(*c.*) Universal handle for four porcelain cauterizers. Intestine cauterizer. Tooth cauterizer.

(*d.*) Tonsil cutter, for cauterizing the almond glands.

Kgl. chirurgische Klinik der Univ. Breslau (*Prof. Dr. Fischer*).

3949b. Case, with two cautery handles, and six small cauteries for dentists.

Kgl. chirurgische Klinik (*Prof. Dr. Fischer*), *Breslau.*

3949c. Case, with larynx instruments.

Kgl. chirurgische Klinik (*Prof. Dr. Fischer*), *Breslau.*

3949d. Complete Case.

Kgl. chirurgische Klinik (*Prof. Dr. Fischer*), *Breslau.*

3949e. Case, containing the most necessary cauteries for practical surgeons.

Kgl. chirurgische Klinik (*Prof. Dr. Fischer*), *Breslau.*

3949f. Winterich's Lamp. *Friedrich Heller, Nuremberg.*

The instrument is very convenient for illuminating the throat.

3950. Hatching Apparatus at a uniform temperature; length 57 c., width 23, height 70 centims.

The apparatus was made in 1850, but not described. In the interior of the hatching apparatus is placed a metallic thermometer, the vertical axis of which passes through the bottom, and carries, underneath the hatching apparatus, a horizontal branch. At the end of the latter there is a chimney which, at a given temperature, is brought over the flame and diverts the hot air from the chimney which is placed in the water of the apparatus.

Prof. Théodore Schwann, Liége.

3950a. Apparatus for Aërating the water in Aquaria.

Prof. U. J. Van Ankum, Director of the Zoological Laboratory of the University of Groningen.

3950b. Elevations and Plan of the Laboratory for Biological Research, presented to the Royal Gardens, Kew, by T. J. Phillips Jodrell, Esq. *H.M. Board of Works.*

3950c. Model of a Cupboard 3′.11″ high; 2′ broad; 1 deep, enclosing 2 cylinders.

1. Complete, with 4 circular shelves.
2. In section, to show the internal structure of the whole.

Laur Esmark, Christiania.

The shelves are made to save room in museums in arranging specimens preserved in spirits of wine. The cylinders are to be turned round, so that the glass jars, which are placed along the periphery of the circular shelves, can be easily seen or taken out, instead of their being arranged as is generally the case in museums in a straight line, taking double or treble space. In some glass jars is to be seen the manner in which the specimens are fixed to glass threads, which prevent their coming in contact.

3950d. Page's Gas Regulators (2). *E. Cetti and Co.*

3950e. Geissler's Gas Regulator. *E. Cetti and Co.*

SECTION XIX.—EDUCATIONAL APPLIANCES.

SOUTH GALLERY, ROOM A.

4000. **Apparatus** for **Instruction** in **Physical Science.**

Aug. Bel and Co.

1. Thomas's apparatus for showing pressure produced by dilation of liquids. 2. Daniel's hygrometer, for measuring the hygrometic state of the air. 3. Gravesande's hygrometer, for showing the expansion of metal by heat. 4. Bar of iron and copper for showing unequal expansion. 5. Apparatus to show the formation of vapour in a vacuum. 6. Air pump for producing a vacuum. 6*a*. Receiver for ditto. 7. Air pump. 7*a*. Receiver for ditto. 8. Air pump with glass barrel. 8*a*. Receiver for ditto. 9. Long glass tube mounted to show that heavy and light articles fall with equal rapidity in a vacuum. 10. Wire cage. 11. Heron's fountain for showing the elastic force of compressed air. 12. Water hammer (singing). 13. Haldat's apparatus for showing that the pressure of liquids depends upon their height and the surface of the bottom of the columns, and not upon the capacities of the vases. 14. Bunsen's spectroscope, for spectral analyses. 14*a*. Burners for ditto. 14*b*. Platina wire holder for ditto. 15. Hofmann's spectroscope (2). 16, 17. Polariscopes (5). 18. Magnesium lamp. 18*a*. Phosphorescent tube. 19. Newton's coloured disc for producing white light by rapid rotation. 20–23. Bichromate of potash batteries. 23*a*, 23*b*. Ditto, large. 24. Grenet's battery. 25. Induction coil. 26, 27. Apparatus for decomposition of water. 28. Galvanometer. 29. Apparatus for rotation of liquids by the electric current. 30. Ditto with hollow magnets. 31. Apparatus to show the attraction current. 32. Roget's spiral, for showing ditto. 33. Apparatus to show that the electric spark will not pass in a complete vacuum. 34. Astatic needle. 35. Secondary current apparatus. 36. Telegraph (two parts). 37. Smee's battery, six cells. 37*a*. Grove's ditto, five cells. 37*b*. Bunsen's battery. 37*c*. Set for electrotyping. 38. Set of mechanical powers. 39. Endless screw. 40. Centrifugal machine, four parts. 40*a*. Double cone. 40*b*. Electroscope. 41. One sportsman. 42. Sparkling jar. 43. Electroscope. 44. Whirl. 45. Egg. 46. Set of seven bells. 47. Apparatus for making a hole in a sheet of glass by the electrical discharge. 48. Diamond jar. 49. Henley's table. 50. Discharging rod. 51. Hand spiral. 52. Two brass plates for pith figures. 53. Electrical swing. 53*a*. Holtz electrical machine. 53*b*. Leyden jar, with movable coating. 53*c*. Electroscope. 53*e*. Jar with pith balls. 53*f*. Discharging table. 53*g*. Ditto rod. 54. Geissler's tube for showing direction of the current. 54*a*. Stand for ditto. 55–66. Vacuum tubes and stands. 67. Box of five tubes. 68. Tube and stand. 69. Ditto. 69*a*. Magneto engine for revolving vacuum tubes, &c. 70. Copper hot water funnel. 71. Still and condenser. 72. Small japanned pneumatic trough. 73. Large ditto. 74. Copper water bath, nickel plated. 75. Galvanised iron press. 76. Enamelled cast-iron air bath. 77. Bunsen's filter pump. 78. Ditto, modified by Dr. Frankland. 79. Copper oxygen retort and stand. 80–81*a*. Berzelius spirit lamp. 82. Revolving test tube stand. 83. Twelve holes and pegs, black. 84. Ditto, with glass pegs. 85. Ditto, in two stages. 86, 87. Test

tubes in two sizes for the above stands. 88. Bunsen's mercury trough. 89. Mahogany funnel stand for two. 90. Ditto, for one. 91. Stand for eight burettes. 22. Eight burettes for ditto. 93. Universal holder. 94. Two Geissler's burettes for ditto. 95. Universal holder. 96. Retort for ditto. 97. Bunsen's universal holder. 98. Table stand. 99–102. Bunsen's burner. 103. Steatite ditto. 104–106. Bunsen's ditto. 107, 108. Bunsen's blast burner. 109, 110. Bunsen's gas blowpipe. 111. Oxygen hydrogen burner. 112. Hoffmann's apparatus to show that 2 vols. of H. & 1 vol. of O. produce H. 2 O. 2 vol. 113. Burette stand for ditto. 114. Ozone tube. 115. Two stands for ditto. 116–118. Chemical balance. 119. Plattner's ditto. 120. Set of 1 gramme weight. 121. Ditto 50 ditto. 122. Ditto 100 ditto. 123. Ditto 6,000 grain. 124. Ditto 100 gramme weight, common. 125. Ditto 1,000 ditto. 126. Retort stand, galvanised foot. 126. Ditto, brass rings, clamp, and block. 127. Ditto, triangular foot. 128. Large retort stand, two clamp burner. 129. Bunsen's apparatus for determining the specific gravity of gas by effusion. 130. Glasshilig's condenser stand. 131. Aug. Belsder's crucible furnace (according to Perrot, Geneva). 132. Ditto, smaller (according to Forgnigum and Leslere). 133. Glasser's combustion furnace. 134. Hofmann's ditto. 135. Kekuli ditto. 136. Dr. Würtz ditto. 137. Large Bunsen's burner. 138. Tripod for ditto. 139. Funnel with stop-cock. 140. Set of bottles for mounting microscopic objects. 141. 5 decigallon jars. 142. 1,000 cc. ditto graduated jar. 143. 700 ditto. 144. 500 ditto. 145. 300 ditto. 146. 200 ditto. 147. 100 ditto. 148. 25 ditto. 149. 1,000 ditto, stop. 150. 500 ditto. 151. 300 ditto. 152. 75 ditto. 153. 25 ditto. 154, 155. Two cylindrical jar stops. 156, 157. Two cylindrical jars, plain. 158. Hydrogen gas bottles. 159. Eprouvette. 160–162. Three Woulff's bottles, assorted. 163, 164. Two Woulff's bottles. 165. One ditto, tubulated. 166–170. Five test glasses, assorted. 171. Lixiviating jar. 172–175. Four capsules. 176. Parting flasks. 177, 178. Two conical beakers. 179–182. Four flasks, assorted. 183–185. Three Berlin basins. 186, 187. Two conical flasks. 188. 750 cc. flask. 189. Set of three beakers. 190. Ditto four ditto, spouted. 191. Set of nine glass basins. 192. One decigallon flask. 192*a*, 193. Two basins. 194. 250 decim flask. 195. One retort. 196, 197. Two retorts. 198–200. Three receivers. 201. Bottle flasks. 202. Jar. 203, 204. Two specimen bottles. 205, 206. Florentine receiver. 207. French balloon. 208–214. Seven bottles, assorted. 215. Percolator. 216. Gas bottle. 217. Water bottle with tap. 218–221. Four funnels. 222, 223. Two spirit lamps. 224. Apparatus to prove that the mixing of chlorine with hydrogen into hydrochloric acid does not alter the volume, therefore one volume of hydrogen and one volume of chlorine produce two volumes of hydrochloric acid. 225. Geissler's potash bath. 226. Carbonic acid apparatus. 227–231. Five blow-pipes. 232. Spee gear, bottle in case. 233. Mercurial trough. 234. Ditto, ditto. 235. Pestle and mortar. 236, 237. Two Berlin capsules. 238. Desiccating pan. 239. Porcelain plate twelve cavities. 240. Copper condenser and stand. 241. Complete set of apparatus according to Gay Lussac for assaying silver by wet process. 242. Copper gas holder. 243. Vertical galvanometer for lectures.

SOUND.

301. Eight pieces of wood sounding the scale. 302. Opening pipe allowing a view of the interior of the pedal. 303. Wertheim's apparatus, new model. 304. Organ pipe with glass facing, and showing vibration of sound. 305. Organ pipe with changeable openings. 305 *bis.* Four organ pipes, all containing the same quantity of air ; one cylindrical, one cubical, one spherical, and one tetrahedral. 306. Three organ pipes, all containing the same quantity

of air; one prismatical, one straight conical, one reversed conical. 307. Organ pipe with glass furnace, according to Mr. Bourbouze, showing three different vibrations with reflector. 308. Five different sounding boards in wood, and one of wire. 309. Two flat wires for horizontal vibration. 310. Small support with movable bridges to fix the wire or sounding boards. 311. Sinometer, according Mr. Barberau. 312. Circular membrane in caoutchouc with changeable tension. 313. Ditto of paper, 30 cent. diameter. 314. Ditto, ditto, 30 cent. thick. 315. Two tuning forks in C, mounted upon wooden box adjusted to give four vibrations in the second. 316. Two tuning forks in C, mounted between magnetic poles, and intermitting tuning fork in C. 317. Vibration meter according M. Duhamel. 318. Apparatus showing the vibration through liquids. 319. Small apparatus, showing the vibration of vocals without movable reflector.

EXAMPLES OF ELEMENTARY PHYSICAL APPARATUS.

The pieces of apparatus in this collection were made by the pupils Messrs. Boughton and Owen in the Physical Laboratory at the Science Schools, South Kensington. They are intended to show what can be done by Science students in the matter of making their own apparatus, and to indicate that neither great expense nor great manipulative skill is required to put such students in possession of instruments capable of illustrating the ordinary laws and phenomena of physics.

Frederick Guthrie.

PROPERTIES OF AIR AND WATER.

4000a. Cardboard Mercury Tray.

4000b. Glass Millimetre Scale.

4000c. Boyle's Tube.

4000d. Siphon Barometer.

4000e. Water Hammer.

4000f. Specific Gravity Bottle.

4000g. Apparatus for estimating density of Mercury.

SOUND.

4000h. Monochord.

4000i. Compound Motion Spring.

4000j. Sensitive Flame.

4000k. Singing Flame Apparatus.

4000l. Singing Flame Apparatus [octave higher].

HEAT.

4000m. Differential Thermometer.

4000n. Alcohol Thermometer.

4000o. Mercury Thermometer.

4000p. Bulb for determining Expansions.

4000q. Apparatus for measuring Absolute Expansion of a Liquid.

4000r. Flask with Delivery Tube.

4000s. Conductivity Cones.

4000t. Hygrometer.

4000u. Ventilation Apparatus.

LIGHT.

4000v. Pin Hole Camera.

4000w. Instrument for measuring Vertical Heights.

4000x. Circle Dividing Board.

4000y. Multiple Image Apparatus.

4000z. Concave Mirror.

4000aa. Convex Mirror.

4000ab. Three Glass Bulbs and Beakers.

4000ac. Glass Cell.

4000ad. Bisulphide of Carbon Prism.

4000ae. Spectroscope.

4000af. Polariscope.

FRICTIONAL ELECTRICITY.

4000ag. Glass Tube.

4000ah. Amalgamed Silk Rubber.

4000ai. Balanced Glass Tube.

4000aj. Pointed Support for Glass Tube.

4000ak. **Pith Balls with Insulating Threads.**

4000al. **Insulating stand for Insulating Threads.**

4000am. **Proof Plane [glass].**

4000an. **Proof Plane [sealing wax].**

4000ao. **Proof Plane [ebonite].**

4000ap. **Insulated Flannel Rubber.**

4000aq. **Gold Leaf Electroscope.**

4000ar. **Shellac Rod.**

4000as. **Flannel Rubber for Shellac Rod.**

4000at. **Sealing Wax.**

4000au. **Flannel Rubber for Sealing Wax.**

4000av. **Cylindrical Conductor on Insulating Stand.**

4000aw. **Conical Conductor on Insulating Stand.**

4000ax. **Spherical Conductor with Insulating Thread.**

4000ay. **Spherical Conductor with Insulating Thread.**

4000az. **Insulating Stand for Spherical Conductor.**

4000ba. **Insulating Stand for Spherical Conductor.**

4000bb. **Insulating Plate.**

4000bc. **Condenser.**

4000bd. **Fulminating Plate.**

4000be. **Bennett's Multiplying Condenser.**

4000bf. **Leyden Jar Discharger.**

4000bg. **Oval Conductor on Stand.**

4000bh. **Electrophorus Cover.**

4000bi. **Reversible Net.**

VOLTAIC ELECTRICITY.

4000bj. **Coil of Wire on Glass Tube.**

4000bk. **Zinc and Copper Plates.**

4000bl. Astatic Galvanometer.

4000bm. Daniell's Cell.

4000bn. Wheatstone's Bridge.

4000bo. Rheocord and set of Resistance Coils.

4000bp. Electric Bell.

4000bq. Quadrant Electrometer.

4000br. Thermopile.

4000bs. Water Decomposition Apparatus.

MAGNETISM.

4000bt. Two-bar Magnets and Keepers.

4000bu. Magnetized Needle.

4001. Collection of **Models** and **Apparatus** for teaching **Physics, Sound, Light, Heat, Electricity,** and **Chemistry.**

Matthew Jackson.

Tate's air pump.
Magdeburg hemispheres.
Glass globe for weighing air.
Gay-Lussac's apparatus for vapour densities.
Dumas' apparatus for vapour densities.
Electrical alarum.
Savart's toothed wheel apparatus.
Syren.
Tuning forks.
Hopkins' fork tube.
Glass reflectors on stands.
Set of lenses and half lenses, with holder on card.
Fergusson's pyrometer.
Gravesand's ring and ball.
Sir H. Davy's apparatus.
Thermopile.
Cylinder machine.
Plate machine.
Bertsch machine.
Holtz machine.
Winter's machine.
Volta's condensing electroscope.
Aurora apparatus.
Bichromate battery.
Zinc plates for Bunsen's battery.
Tangent galvanometer.
Set (11) of Hofmann's tubes with stands (1, with 2 stands) and 1 span stand.
Winkler's gas apparatus.
Imp. sulph. hydrogen apparatus. 3 articles.
Ammonia apparatus.
Collection of small instruments (18) on cardboard.
Organic analysis apparatus. 30 pieces.
Desiccators. Different patterns.
Distilling apparatus for carbon bisulph. (4 articles.)
Assortment of 12 test glasses.
Distilling apparatus. (4 pieces.)
Set of 71 graduated and other glass instruments.
Carbonic acid apparatus. 7 portions in card boxes.
Arrangement of gas burners.
Bunsen's water bath and stand.
Sulph. hydrogen apparatus.
Cleaning brushes.

Wide tube, graduated tube, and thermometer for Gay-Lussac's apparatus.
Bulb and thermometer for Dumas' apparatus.
Hofmann's tube for steam, with glass worm and stand.
Cabinet with 26 bottles.
Glass tube, two nitrogen bulbs, and piece of india-rubber tubing for organic analysis apparatus.
Four weighing bottles for desiccators.
Twelve small tubes for Eggertz's carbon apparatus.
One nest of six beakers with spouts.
One nest of 12 beakers without spouts.
Two tin sand baths.
One Bink's burette 500 cc., on wood stand.
Ritchie's photometer.
Glass carbon and porous cells for Bunsen's battery, 10 each.
Wooden burette stands (5).
Stand for eight burettes.
Bath for Eggartz's carbon test.
Bunsen's clamp stand.
Regulator for Bunsen's water bath.

4026. Th. Müller's Di-Electric Machine, with accessory apparatus, viz. :—

Electric tuft.
Electric turbine.
Electric puppet-dance.
Electric peal of three bells.
Lightning tube.
Lightning conductor.
2 electric excitors.
Electric pistol.
2 condenser jars.

Kgl. Preuss. Oberbergamt, Breslau.

This machine has of late been much used in elementary schools in mining districts of Germany for instruction of the children in some parts of their future calling. With 12⅜ inches diameter of disc, it gives sparks over 4 inches long. The machine can be depended on even in unfavourable weather. It is simple in construction, and the peculiarity of it consists in the collection of the positive and negative electric currents in two separate Leyden jars of special form, which again are so connected together that the opposite electric currents compensate each other. Thus the loss of electricity is reduced to a minimum, and strong actions are obtained with the excited glass surface.

4002. Calculating Disc, constructed on the system of Professor Sonne. Specimen for demonstration, size 50 centimeters, with rough division ; for instruction in schools.

Landsberg and Wolpers, Hanover.

4002a. Universal Lever, for lecturing purposes.

C. Chzechovicz, Russia.

Apparatus consisting of a set of levers and parallelograms, intended to illustrate the principle of elementary statics, viz. :—
The combination of forces applied to a body.
Combination of parallel forces.

Testing of the laws of the lever of first and second class.
Examination of the properties of the balances.
Experimental proof of the proposition that every part of a decomposed force produces a corresponding effect.

4002b. Apparatus for showing the **Propagation** of **Wave-motions.** *C. Chzechovicz, Russia.*

For lecturing purposes, and intended to show the propagation of wave-motion by a system of bi-filar pendulums suspended on movable levers. By changing the plane of suspension, one is enabled to reproduce waves with plane vibrations as well as with elliptical ones.

4002c. Model of a Plummer-block, for use in classes.

4002d. Model of a Chain-holder, for use in classes.

4002e. Group, with photographs of models, for use in classes. *M. J. Prugger, Munich.*

4002f. Glenny's Diagrams of Building Construction (10). *Chapman & Hall.*

4002f. Bristow's Table of British Strata. *Chapman & Hall.*

4002f. Unwin's Machine Details (16). *Chapman & Hall.*

4002f. Patterson's Zoological Diagrams (10). *Chapman & Hall.*

4002f. Goodeve's Steam Diagrams (15). *Chapman & Hall.*

4002f. Etheridge's Diagrams of Fossils (6). *Chapman & Hall.*

4002f. Anderson's Diagrams (2). *Chapman & Hall.*

4003. Arithmometer, by Martinot, for imparting the knowledge of metrical arithmetic and practical geometry. *Alphonse Martinot, Belgium.*

It is composed of one thousand small cubes of the size of one centimetre. Thirty-two of these are isolated, nine hundred and thirty-two others are united in several groups, forming forty-two pieces. There are ten pieces of two cubes, ten pieces of five cubes, thirteen pieces of ten cubes, bound together in the shape of reglets, or scale boards, one piece of twenty cubes, one piece of fifty cubes, and, finally, seven pieces of one hundred cubes, bound together like plane tables.

The apparatus is completed by four racks, into which, not only the isolated cubes, but the greater number of the groups of cubes may be bracketed so as to form, when united, the cubic decimeter, *i.e.*, the 1,000. It is easy to understand what intuitive power this apparatus places at the disposal of the professor, for teaching children, and for making them understand, in what may be called a material way, the principles of numeration, construction, and deconstruction of numbers, the four fundamental rules of arithmetic, fractional decimals, the formation of the square and cube of numbers, the extraction of their roots, and the generation of metrical measures, &c., &c. (Extract from the Report of Mr. André Van Hasselt, Inspector of the Normal Schools of Belgium.)

4003a. Machine for Arithmetical Instruction.
Antoine Arens, Frere Marianus, Rue de Bruxelles, Namur.

APPARATUS FOR INSTRUCTION IN PHYSICAL SCIENCE, CONTRIBUTED BY THE COMMITTEE OF THE PEDAGOGICAL MUSEUM, RUSSIA.

APPARATUS FOR INSTRUCTION IN PHYSICAL SCIENCE IN MILITARY SCHOOLS OF THE HIGHER AND LOWER GRADES IN RUSSIA.

4004. Bauler's Inclined Plane illustrating the acceleration of motion.

4005. Apparatus illustrating the **Expansion** and **Fusion** of **Bodies** from **Heat,** constructed under the direction of the Physical Section of the Pedagogical Museum.

4006. Slides, with weights, for illustrating the force of **Cohesion,** constructed under the direction of the Physical Section of the Pedagogical Museum.

4008. Wheel with Graham's Anchor. By Lermontoff.

4009. Bauler's Lamp, with Gasometer. By Lermontoff.

4011. Caoutchouc Electrical Machine. By Kresten.

4012. Apparatus for preparing Oxygen. By Kresten.

MATHEMATICS.

A.—ARITHMETIC.

4019a. Sets of pegs for integers and fractions.

4019b. Kanaeff's arithmetical box.

4019c. Kanaeff's arithmetical box, coloured.

4019d. Wooden blocks divided into cubes for the **comparison of numbers.**

4019e. Arithmetical boxes, made by the St. Petersburg School Workshop.

4019f. Zitowitch's arithmetical box.

4020. Paulson's abacus for integers.

4020b. Kanaeff's abacus for integers and fractions.

4020c. Model of Ilyin's abacus.

B.—Geometry.

4028a. Collection of 6 geometrical forms. Made by the St. Petersburg School Workshop.

4028b. Strookoff's collection of 7 geometrical forms.

4029a. Collection of 16 geometrical forms prepared by the inmates of a Russian prison.

4033a. Cube of three.

4033b. Cube of a binomial quantity.

4033c. Square of a trinomial quantity.

Cube of a trinomial quantity.

Two-plane angle made of cork.

The Pythagorean theorem.

Four-sided geometrical figures.

Six Polygons.

Boldt's geometrical apparatus.

Zitowich's apparatus for determining the cubic content of geometrical bodies.

Ogerovsky's geometrical puzzle.

Ogerovsky's trigonometrical diagram.

C.—Geometrical Drawing.

Shildknecht's apparatus for demonstrating the theory of projections.

Strookoff's collection of school apparatus for geometrical drawing.

Pantograph.

Ellipsograph.

Specimens of appliances for geometrical drawing, prepared by pupils of one of the military schools.

Physics.

Lermontoff's wheel with Graham's anchor.

Van der Fleet's apparatus for illustrating Marriotte's law.

4012. Kresten's apparatus for preparing oxygen - - - - -

Schwedoff's electrical machine - -

Tepploff's two electrophore machines -

4009. Baulev's lamp, with gazometer -

Not included in the list as not belonging to educational appliances.

Geography.

N.B.—These appliances were exhibited at the International Geographical Exhibition in Paris (1875), and the Museum was awarded a "Lettre de distinction" for them.

A. Propedephtical Course of Geography.

Semenoff's pictures.

Simashko's ideal relief and section of the earth.

Relief of the sea bottom.

Michailloff's globe.

Class Plan of **St. Petersburg.**

Plan of the **Environs** of **St. Petersburg.**

Plan of **Moscow.**

Ilyin's Nets for **Drawing Maps.**

Ilyin's Nets with the **Outlines** of **Continents.**

Michailoff's System of **Drawing Maps** on oil cloth.

System of preparing **Relief Maps** in wax.

Class Orographical Map.

B. PHYSICAL GEOGRAPHY.

4049. Phenomena of nature in pictures.

Girotovsky's geyser.
„ icebergs.
„ attol.

Michailoff's gletchers.
„ sand spouts.

Teich's Russian obos (train of carts).
„ bargemen-work on Wolga.

Karagin's steppes and deserts (two pictures).
„ sea of Aral.
„ A caravan in the steppes.
„ Barkhanes (sand-hills in Turkistan).
„ the steppes in middle Asia.

Albums with views.

C. POLITICAL GEOGRAPHY.

Ilyin's school geographical atlases.

Ilyin's detailed school atlas of the Russian empire.

Ilyin's atlases of the Russian empire for elementary schools.

Ilyin's wall maps of the five parts of the world.

Ilyin's wall maps of the Russian empire.

Ilyin's detailed atlas of the Russian empire.

Ilyin's detailed atlas of Asiatic Russia.

Ilyin's post map of the Russian empire.

Ilyin's railway map of the Russian empire.

Ilyin's map of Finland.

Ilyin's maps of Poland.

Ilyin's map of Turkistan government.

Ilyin's map of Caucasus.

D. ETHNOGRAPHY.

Specimens of **Models** showing the national costumes of the different inhabitants of Russia.

4058. Types of races of man (models made of papier-mâché).

Busts of large size.

Busts of middle size.

Busts of small size.

Frames with busts in bas-relief.

Svetchnikoff's ethnographical map of Russia.

Mirkovitch's ethnographical map.

E. MATHEMATICAL GEOGRAPHY.

Model of Foucault's apparatus.

Tellurium.

4079. Kachovsky's apparatus for explaining the seasons.

Kachovsky's apparatus for explaining the formation of the ecliptic.

4080a. Apparatus for explaining the phases of the moon (without a lamp).

Kachovsky's apparatus illustrating the motion of the upper and lower planets.

Brouns' astronomical atlas.

Petchorin's atlas of mathematical geography.

MATHEMATICAL INSTRUMENTS.

4019. Board, with set of pegs, for exercises in studying numbers from 1 to 1,000. Made by the St. Petersburg Workshop for School Apparatus.

4020. Arithmetical Boxes, for exercises in numbers. Made by the St. Petersburg Workshop for School Apparatus.

4021. Kachovsky's Class Abacus, for integers and fractions. Made by the St. Petersburg Workshop for School Apparatus.

4022. Kachovsky's Abacus, constructed on the system of the St. Petersburg Workshop of School Apparatus.

4023. Nomansky's Abacus, for integers and fractions.

4024. Russian Trade Abacus.

4025. Collection of Measures, for use in schools. (Long, superficial, and solid measures, weights, &c.)

GEOMETRICAL APPARATUS.

4027. Board, exhibiting square foot divided into square inches. Made by the St. Petersburg Workshop for School Apparatus.

4028. Cubic Quarter Arshin, divided into cubic vershoks. Made by the St. Petersburg Workshop for School Apparatus.

4029. Collection of Geometrical Forms, with sections. 17 models. Made by Stroukoff.

4030. Collection of 37 geometrical forms intersecting each other. Made by Stroukoff.

4031. The Cube of two, the cube of three, the cube of a binomial and a trinomial quantity. Made at the St. Petersburg Workshop of School Apparatus.

4032. Large Cone, with sections and hemispheres for determining the focus of curves. Made by Stroukoff.

4033. Sphere with sections. Made by Stroukoff.

4035. Apparatus for demonstrating the theory of projections. Made by Schildknecht.

4038. Collection of class school apparatus for geometrical drawing. Made by Stroukoff.

4039. Manuals and Exercises on all branches of mathematics and geometrical drawing; treatises on the method of instruction in these subjects, adopted in the military schools of Russia. Published by Fenoult.

MAPS, DIAGRAMS, MODELS, AND OTHER APPLIANCES FOR TEACHING GEOGRAPHY AND ASTRONOMY.

4040. Apparatus illustrating the **Motion** of the **Planets** in general, and demonstrating the periods of the transit of Venus in particular, by Kachovsky.

4042. Geographical Pictures on glass for the magic lantern, by Ermolin.

4043. Atlas of Relief Maps. Published by the Juvenile and Pedagogical Library in Moscow.

4044. Relief Map of Asia. By Shulgin.

4045. Model in Relief of an Alpine country. Prepared by pupils.

4046. Orographical Maps of **the World.** By Simashko.

4047. Maps of the five divisions of **the World,** By Ilyin.

4048. Charts (two), showing the distribution of **Forests** and **Mineral Wealth of Russia.** Prepared by the Statistical Committee.

4049. Phenomena of Nature, in pictures :—

Givotovsky's Geyser, Toundra, Icebergs, and Attols.
Michailoff's Glaciers and Sand Spouts.
Teich's Russian Obos (train of carts), and Bargemen at work on the Volga.
Karasin's Steppes and Desert, two pictures; Sea of Aral, a Caravan in the Steppes, Barkhanes (sand hills in Turkistan), and The Steppes in Middle Asia, two views.

4050. Specimens of **Ermolin's Geographical Pictures** on glass for the magic lantern.

4052. Ilyin's Aids for Pupils in **Map Drawing,** with the outlines of the continents filled in.

4053. Terrestrial Globes of different dimensions, prepared by the Juvenile and Pedagogical Library in Moscow.

4054. Album with views of Lapland (travels of Nemirowitch Danchenks).

4055. Album with views of Polessie (the marshes of Pinsk). Views drawn according to a project for draining the marshes, by Colonel Gilinsky, with charts and plans.

4056. Photographic Views of Amoor, Western and Eastern Siberia, and Ural, five large vols. in folio.

4057. Atlas of **Physical Geography,** by Zooeff.

4058. Types of Races of Man. Models made of papier-mâché (busts of large, middle, and small dimensions, busts in bas-relief, statues, etc.). Prepared by Heiser and Female Workshop.

4059. Races and Tribes of Man. Drawings, published by the Juvenile and Pedagogical Library in Moscow, and Ilyin's Chartographical Establishment.

Only specimens will be shown, the Museum being obliged to send the collections to the American Exhibition in Philadelphia.

4060. Ethnographical Charts of Keppen, Mirovitch, and Sweshnikoff.

4061. Ethnographical Album, by Pauli.

4064. Atlas of Russia, by Ilyin.

4065. Atlas of Russia in detail, by Ilyin.

4066. Rothstein's Atlas of the Russian Empire.

4067. Geographical Atlas (of all countries), by Ilyin.

4068. Atlas of the five parts of **the World,** by Ilyin.

4069. Jordan's Geographical Atlas.

4070. Illustrated Geographical Atlas, by Limberg.

4071. School Atlas, as projected by Colonel Ponlikoffsky.

4072. Geographical Wall-maps, of Ilyin, Rothstein, Sheveleff, Lebedeff, Zooeff, and Michailoff.

4073. Elementary Course of Geography. Systematically arranged in drawings, plans, and maps, prepared by Lapehenko and Michailoff.

4074. Apparatus for teaching the Blind. Collections of plans, maps, manuals, and models for teaching geography to the blind. Prepared and edited by General Grigorieff, director of the Institution for Blind Children in St. Petersburg.

4075. Manuals on all branches of **Geography,** adopted in the Military Schools of Russia; published by Fenoult.

4077. Atlas, by Petchorin.

4079. Apparatus for explaining the seasons (formation of the ecliptic), by Kachovsky.

4080. Apparatus for explaining the phases of the moon, by Kachovsky.

4081. Armillary Sphere, by Penkin.

4082. Armillary Sphere, by Koualsky.

NATURAL HISTORY.

4089a. Charts illustrating natural history, issued under the direction of the Imperial Economical Society. Published by Fenoult.

4089b. Arend's School Atlas of Natural History. Published by Fenoult.

1. SCHUBERT'S ZOOLOGICAL WALL CHARTS. Published by Fenoult.
2. MICHAILOFF'S SCHOOL ATLAS OF ZOOLOGY. Published by Fenoult.
3. MEINHOLD'S ANATOMICAL TABLES. Published by Fenoult.
4. CARUS' TABLES OF COMPARATIVE ANATOMY. Published by Fenoult.
5. BRANDT'S ATLAS OF COMPARATIVE ANATOMY. Published by Fenoult.
6. BOCK'S ATLAS OF COMPARATIVE ANATOMY. Published by Fenoult.

4089c. Specimens of prepared Skeletons and their parts: the skeleton of the bat, of the cat; cervical and lumbar vertebra in section; horn of the bull with the core; leg of the horse; hoof and skull of the same. Prepared by Strembitsky.

(NOTE.) The committee consider it unnecessary to send complete school collections of skeletons and stuffed animals, and prefer sending a few specimens only, in order to show the mode of preparation, the price of articles and their use in teaching.

4089d. Collection of Furs. Prepared by Fenoult, and at the St. Petersburg Workshop of School Apparatus.

4089e. Specimens of **stuffed Mammalia** (cat and bat). Prepared by Fenoult, and at the St. Petersburg Workshop of School Apparatus.

ANATOMICAL MODELS, A COLLECTION PREPARED BY STREMBITSKY IN ACCORDANCE WITH THE INSTRUCTIONS OF THE NATURALISTS OF THE PEDAGOGICAL MUSEUM COMMITTEE.

4089f. Thorax (with the same details as Bock Stagger's).

4089g. Vertical section of the Head, with removable larynx.

4089h. Vertical section of the Cerebrum.

4089i. Human Mask, the mouth open.

4089j. Lungs, Heart, and Larynx.

4089k. Heart.

4089l. Larynx, from behind.

4089m. Larynx, with soft movable epiglotis and elastic communication of the hyoides with the thyroid cartilage.

4089n. Organ of Hearing.

4089o. Eye.

4089p. Spinal Cord and Cerebellum.

4089q. Lower Jaw (organization and progressive development of teeth).

4089r. Vertical section of the Skin.

4089s. Models of Joints (three).

4089t. Complete Model of a man. (2½′ high.)

4089u. Model of a human **Tooth.**

4089v. Models showing the anatomy and physiology of animals; stomachs of ape, kangaroo, tiger, armadillo, seal, manatee. Prepared by Strembitsky.

4089w. Heiser's Models of mammalia (papier-mâché). Prepared by Schindhelm.

4089x. Birds. Specimens of skeletons and their parts; the skeleton of the turkey, with wing and tail feathers; skeleton of the fowl; sternum, wing, foot, skull of the same. Prepared by Strembitsky.

4089y. Stuffed Birds, two specimens (fowl and linnet). Prepared by Strembitsky.

4089z. Model of digestive organs of a Goose. Prepared by Strembitsky.

4089aa. Skeleton of a Frog, Skull of a Poisonous Snake. Exhibited as specimens of skeletons of amphibia and reptilia. Prepared by Strembitsky.

4089ab. Frog in different stages of development. Exhibited as a specimen of preparation of amphibia in alcohol. Prepared by Strembitsky.

4089ac. Frog. Exhibited as specimen of stuffed amphibia. Prepared by Strembitsky.

4089ad. Collection of preparations in wax, illustrating the development of the frog. Prepared by Strembitsky.

4089ae. Skeleton of the Perch. Exhibited as specimen of skeletons. Prepared by Strembitsky.

4089ah. Specimen of stuffed fish. (Sturgeon.) Prepared by Strembitsky.

4089al. Dissected Insects, two specimens (a beetle and a locust). Prepared by Strembitsky.

4089am. Class collection of Insects, containing 25 typical forms. Prepared by Strembitsky.

4089an. Class collection of Insects on coloured plants, prepared by Vaviloff and the pupils of one of the military gymnasia.

4089ao. Class collections of Insects, the insects stuffed and arranged in characteristic postures on natural branches. Prepared by Strembitsky.

4089ap. Specimens of a class collection of insects in separate glass boxes (idea of St. Hilaire).

4089aq. Larvæ of different butterflies, dried (the colour retained). Prepared by Strembitsky.

4089ar. Model of the head of *Œstrus* with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

4089as. Model of the head of *Libellula* with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

4089at. Model of the head of a spider with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

4089au. Model of the head of a butterfly with movable parts of the mouth (greatly enlarged). Prepared by Strembitsky.

4089av. Model of the leg of an insect, joints movable (greatly enlarged). Prepared by Strembitsky.

4089aw. Wax Model of the larva of *Meloloutha* (greatly enlarged). Prepared by Strembitsky.

4089ax. Model of *Bombyx mori,* in three stages of its development (vulcanized india-rubber). Prepared by Strembitsky.

4089ay. Collection containing six typical forms of Crustacea. Preserved in alcohol by Strembitsky.

4089az. Specimen of *Astacus fluviatilis.* Prepared in a special manner by Strembitsky.

4089ba. Collection of Crustacea, 10 typical forms, living in Russia (in form of a table). Prepared by Strembitsky.

4089bb. Collection of 5 typical specimens of Vermes in alcohol. Prepared by Strembitsky.

4089bc. Collection of three specimens of Mollusca in alcohol. Prepared by Strembitsky.

4089bd. Collection of 10 artificial specimens of Mollusca, representing them in motion to show the form of their bodies. Prepared by Strembitsky.

4089be. Collection of 17 artificial specimens of Mollusca. Prepared according to the instruction of Professor Owsiannikoff by Strembitsky.

4089bf. Sea Urchin, in alcohol. A specimen of the mode of preserving Echinodermata, Acalepha, Polypi, and Polycistina. Prepared by Strembitsky.

4089bg. Botanical Wall Charts. Prepared by Givotovsky.

4089bh. Botanical Hand Atlas. Published by Givotovsky.

4089bj. Botanical Atlas, by Schubert. Published by Fenoult.

4089bk. Wall Botanical Charts, one specimen of a collection. Coloured on oil-cloth. Prepared in the Military Gymnasium of Orenburg.

4089bl. Dendrological Collection. Illustrations of the trees of Russia. Prepared by Stolpiansky.

4089bm. Dendrological Collection. Illustrations of the trees of Russia. Prepared by Stroukoff.

MODELS AND OTHER APPLIANCES FOR TEACHING MINERALOGY AND CRYSTALLOGRAPHY.

4084. Class Collection of Minerals, with apparatus for their investigation (Heard's system), prepared by Latkin.

4085. Glass Crystals, with axes, illustrative of crystallography, prepared by Skibinevsky.

4086. Glass Crystals, intermediate forms, illustrative of crystallography, prepared by Skibinevsky.

4087. Crystals of Tin (specimens), prepared by Colonel Vonder-Weld.

4088. Models of Crystals in Wood, illustrative of crystallography, prepared by Stroukoff.

4089. Aquarium, Terrarium, and various apparatus for aiding pupils in forming zoological, botanical, and mineralogical collections. From the St. Petersburg Workshop of School Apparatus.

4090. Teacher's Portable Lecture Set, for demonstrating the principles of the science of **Sound,** comprising the following apparatus :—

1. For demonstrating the mode of Propagation of Sound.
   Model to show propagation of wave by the oscillation of a row of particles. The difference between the waves of sound and light is shown by the production of both simultaneously in close proximity. Row of marbles in grooved board.
2. For demonstrating the Necessity of a Conducting Medium.
   Air pump, 6-inch plate, with open receiver fitted with collar and sliding rod. Small bell on cushion.
3. For demonstrating the Reflection and Refraction of Sound.
   Tube, 2 inches diameter, and 6 feet long, with mouthpiece and trumpet-shaped end ; pair of 18-inch tin reflectors ; goldbeater's skin balloon.
4. For demonstrating the Lengths of Waves, Regularity, Music, and Noise.
   Tuning-fork, with steel points set in frame with groove and smoked glass slides ; whirling table with toothed wheel and card and perforated disc ; Trevelyan rocker and lead block.
5. For demonstrating the laws of the Vibrations of Strings.
   Iron frame, with stretched piano wire to show need of sounding board ; sonometer with four wires (two stretched by keys and two by weights), graduated decimal scale, movable bridges, paper riders, and extra strong bow ; elastic cord, 15 feet long, with attachment for whirling table.
6. For demonstrating the laws of the Vibrations of Air-columns.
   C, tuning-fork and glass jar ; glass tube, 1 inch diameter, 2 feet long, open at both ends ; set of 13 organ pipes with bellows and wind chest ; pipe, with sliding stopper for beats ; pipe, with glass slide and paper tray for showing position of node ; metal reed pipe ; harmonium reed large model ; burner for sounding flame, and set of glass tubes.
7. For demonstrating the laws of the Vibrations of Bells.
   Bell glass, 8 inches diameter, and squares of blotting paper ; 3-inch bell on stand ; 3-inch bell mounted for heating.
8. For demonstrating the laws of the Vibrations of Plates.
   Set of two glass and two brass plates, 6 inches diameter, with stand and thumbscrew ; box of silver sand.
9. For demonstrating the laws of Longitudinal Vibrations of Rods.
   Glass tube, $\frac{1}{2}$-inch diameter, 3 feet long, sealed at one end ; lycopodium ; brass rod, $\frac{1}{2}$-inch diameter, 3 feet long ; flannel, leather, and rosin.

10. For illustrating the production of Vocal Sounds.
    Wooden funnel, with stretched membrane.
11. Diagrams.
    (*a.*) Interference of sound.
    (*b.*) Section of organ pipe.
    (*c.*) Formation of nodes on a string.
    (*d.*) Human ear.
    (*e.*) Human larynx.

Matthew William Dunscombe, Bristol.

4091. Teacher's Portable Lecture Set for demonstrating the principles of the science of **Light,** comprising the following apparatus :—

1. For demonstrating the Velocity of Propagation.
   Movable diagram showing Roemer's observation.
2. For demonstrating the Undulatory Theory.
   Model showing propagation of wave by series of rotating particles. The difference between the vibrations of waves of light and sound is shown by the production of both simultaneously in close proximity.
3. For demonstrating the Law of Inverse Squares and Relative Intensities of Lights.
   Two square frames, one four times the area of the other, fitted at the corners to four wires, representing rays of light diverging from a point; Wheatstone's photometer, a new and highly improved form ; discs of paper in frame with oiled spot for Bunsen's method.
4. For demonstrating the Laws of Reflection :
   (*a.*) By plane mirrors.
   Plane mirror and candle; pair of mirrors fringed for showing principle of kaleidoscope ; movable model (quite new), showing law of angular velocity in ray reflected by rotating mirror.
   (*b.*) By curved mirrors :
   Convex and concave silvered glass mirrors, carefully worked ; semi-cylindrical mirror to show caustic curves ; three movable models illustrating the properties of the foregoing.
5. For demonstrating the Laws of Refraction :
   (*a.*) At plane surfaces.
   Equi-angular glass prism on jointed pillar; disc painted with lines showing paths of incident and refracted rays, for immersion up to the centre in water; movable models to show the law of lines and passage of a ray through a sheet of glass with parallel faces ; right-angled glass prism on pillar, to show total internal reflection.
   (*b.*) Three-inch diameter double convex lens on pillar and

ground-glass screen; set of six semi-lenses: movable models to show refraction by convex and concave lenses.

6. For demonstrating the Laws of Chromatics:

Set of coloured discs to fit whirling table; achromatic pair of prisms on jointed pillar.

Matthew William Dunscombe, Bristol.

4092. Geography Teaching Apparatus:—

1. Physical and hypsometrical wall map of Belgium, 1·75 metre by 1·60.

2. Hypsometrical wall map of Europe in three colours, 2 metre by 1·75 metre.

3. Physical, political, and commercial wall map of the World, in three colours, 2 metre by 1·75 metre.

4. Oil cloth board map of Belgium and Europe for chalk exercises, 1·30 metre by 1·75 metre.

5. Hypsometrical submergible relief, for facilitating the study of maps, painted plaster, 0·35 metre by 0·30.

6. Typical landscape in relief, painted plaster, for studying geographical nomenclature, 0·70 metre by 0·60 metre.

7. Several classical atlases (chromolithographic).

8. Series of hartographical exercises, for the use of students.

9. Manuals for masters and pupils.

Alexis M. Gochet, Professor at the Normal School of Carlsbourg (Belgian Luxemburg).

4092a. From Mottershead & Co., Manchester.

Figure plates.
Thick horse shoe magnets.
Pair of magnets.
Tate's air pump and receiver.
Small air pump and receiver.
Concave and convex mirrors.
Bottle prism.
Sets of phosphorescent powders.
Copper drying oven, with regulator.
Copper still and condenser.
Liebig's condenser.
French blast spirit lamp.
Books of chemical labels.
Electro-magnet.
Galvanometer.
Bladder frame and weights.
Prism mounted on stand.
Specimen of crystallized bismuth, with glass shade.
Combined Holtz and Bertsch electrical machine.
Pair bismuth and antimony.
Bar to show different expansion of metals.
Voltameter.
Oersted's experiment.
Jewsbury's reflecting polariscope without Nicol's prism.
Bobbin to show induction.
Madgeburg hemisphere.
Electroscope, with condenser.
Vulcanite electrophorus.
Rammelsberg's air bath.
Set of apparatus and chemicals according to Roscoe's primer.

4092b. Apparatus from J. J. Griffin & Sons.

Oil lamp furnace, with Griffin's blowing machine for the fusion of metals at high temperatures.
Griffin's patent blast gas furnace, with
Gas burner, 16 jets, and a selection of internal fittings.
Iron tripod stand.
P. P. cylinder and crucible.
Fireclay ventilator.

Fireclay cone.
,, plates.
P. P. crucible and cover.
Blowing machine for do., with weights.
Blast gas burner, 26 jets, with stand and crook.
Gas crucible furnace complete, large size.
Gas crucible furnace, complete, small size, and P. P. pots.
Gas muffle furnace, complete, large size.
Gas muffle furnace, complete, small size.
Large muffle and bottle necked.
Small ,, ,,
Large clay atmopyre.
Small ,,
Bone ash cupels.
Plattner's gold assay apparatus.
Pair cupel tongs, with shields.
,, tongs straight, No. 126.
,, ,, bent, No. 127.
,, ,, charcoal tongs bent, No. 120.
,, ,, bent, No. 125.
,, ,, bow, No. 128a.
,, ,, basket, No. 128.
,, ,, bow, No. 124.
,, crucible tongs, No. 4,652.
,, flask tongs, No. 4,576.
Set (4), roasting dishes.
,, (3), cornet pots.
,, (5), scorifiers.
Wrought iron crucible.
,, ,,
Iron cupel mould.
Boxwood cupel mould.
Ingot mould, conical form on foot.
,, ,, ,,
,, with two holes.
,, ,, three divisions.
,, for 12 rods.
Glass parting flask.
Mallet.
Pair boxwood crucible moulds, with three stamps.
Cupeling furnace, with chimney.
Muffle for do.
B. P. tube for do.
Blowpipe set (pocket).
,, in one tin case.
,, in two tin cases in mahogany box.
,, in three tin cases in mahogany box.
Major Ross's blowpipe set (with extras).
Wire stands.
Aluminum plate.
Glass beakers.
G. S. blowpipe with platinum nozzle and stand.
Brass blowpipe lamp.
,, stand.
,, blowpipe.
Stand.
Brass gas blowpipe.
Stand.
Brass Bergmann's blowpipe.
,, German blowpipe.
Stand.
Portable G. S. blowpipe with stand.
Brass ,, ,,
Tin laboratory lamp.
Brass blowpipe on stand.
,, gas blowpipe on stand.
Blowing apparatus.
Tin blowpipe lamp.
Brass stand.
,, pocket blowpipe lamp.
Pair iron tongs, with spoon.
,, brass ,,
,, ,, crucible tongs.
,, ,, tongs, long points.
Platina spoon and cover with handle.
Pair brass tongs with ivory points.
,, platina tongs.
Piece platina foil.
Pair G. S. crucible tongs, with plat. tips.
Patina crucible and cover.
Set of three charcoal borers, with charcoal.
Set of Plattner's cupel supports.
,, lead measure.
Agate mortar and pestle. 2 inch.
,, ,, 2½ inch.
Plattner's roasting furnace.
,, brass sieve.
Platina spoon and handle.
Platnum wire holder and wire.
Plattner's brass scoop.
,, capsule support.
,, crucible support.
,, ,, mould, with boxwood stamps.
,, mould for square blocks.
Albata spoon.
Ivory spoon.
Steel spatula.
Flat file.

Anvil.
Crushing mortar.
„ „ with base.
Blowpipe hammer.
Triple lens.
Single lens.
Coddington lens.
Magnetic and electric needle in case.
„ chisel.
Berlin porcelain cups.
Brass spirit bottle.
Griffin pastille mould, boxwood, and two stampers.
Griffin pastille mould, iron.
Support for sublimator.
Charcoal block and support.
Colour plate and support.
B. P. cup and wire holder.
Cupel support and two cupels.
Set of three watch glasses.
Bunsen's burner and blowpipe jet.
Box powdered glass.
Brass stand.
Wooden blocks.
Set of 100 minerals.
Glass case for do.
Set of 100 blowpipe minerals.
„ 6 Von Kobell's minerals.
„ 120 fragments minerals.
„ 9 Mohr's degree of hardness.

4092c. "Educational Series." Physical and Chemical Apparatus. *J. J. Griffin & Sons.*

Voltaic Electricity and Magnetism.

Thermo-electric Pile, simple form, for school use.

Thermo-electric Pile, very delicate, for investigations.

Galvanometer, vertical needle, simple, for school use.

Galvanometer, astatic, delicate, for use with thermo-piles.

Galvanometer, astatic, for lecturers, with long needle.

Astatic needle, simplest form, on support for demonstration.

Tangent Galvanometer, working model of.

Solenoid, single, with soft iron core, to explain electro-magnets.

Solenoid, double, with soft iron core, to explain induced currents and induction coils.

Pair of *Induction Planes*, copper wires coiled on a plane to exhibit induced currents.

Induction Coil, school form, to give shocks.

Ruhmkorff's Induction Coil, with Grove's battery.

Ruhmkorff's Induction Coil, with Bunsen's battery.

Rheostat, for interposing known resistances.

Electrolysis of water, Buff's apparatus, delivering the gases separately.

Smee's Galvanic Battery.

Model of *Cannon*, fired by electricity.

Faraday's Needle, rotating round a current parallel to itself.

Barlow's Stellar Wheel, rotating between the poles of a magnet.

Sturgeon's Copper Disc, rotating between the poles of a magnet.

De la Rive's Floating Battery, carrying a magnetic solenoid.

Electro-magnetic set of Apparatus, to exhibit the experiments of *Faraday, Ampère, Ritchie, &c.*

Electro-magnetic Machine, with *Siemens' Armature*, for heating wires, firing fuses, decomposing water, &c.

Horse-shoe Magnet, large and powerful, for use on lecture table.

Bar Magnet, suspended in cradle for lecture demonstrations.

Dipping Needle with universal motion.

Ritchie's Rotating Magnet, simplest form.

Soft-iron Discs, Stars, Rods, &c., for illustrating *magnetic induction.*

Hydrostatics and Hydraulics.

Pascal's Apparatus, proving that the pressure depends on the height of the column and the area of the base, and not upon the capacity of the vessels.

Holdat's Apparatus, for proving that the pressure depends on the height of the column and the area of the base, and not upon the capacities of the vessels.

Glass Cone with movable base for determining the pressure on the base of a cone, having a movable bottom.

Apparatus to prove that water presses equally in all directions if pressure be applied to any part of it.

Hydrostatic Bellows, for lifting a heavy weight by the pressure of a column of water.

Bramah's Hydrostatic Press, glass model.

Bramah's Hydrostatic Press, metal model of some power for school use.

Force Pump of Glass, with glass valves and pistons, to facilitate inspection.

Lift Pump of Glass, with glass valves and pistons, to facilitate inspection.

Fire Engine, tin-plate working model of, with double barrels and air chamber.

Hero's Fountain, in which the water jet is caused by the water column compressing the air.

Fountain, intermitting, glass model.

Spring, intermitting, glass model.

Syphon containing a fountain, glass model.

Appold's Centrifrugal Pump, which raises water by the rapid rotation of a small water-wheel.

Archimedean Screw, glass model, to raise water.

Set of *Glass Tubes*, to exhibit the rise of water by capillary attraction.

Simple Glass Vessel to prove that water rises to a level in all communicating vessels.

Vessel to show that water rises to a level in all communicating vessels, superior construction for the lecture table.

Water Wheels, *Set* of *Models*, showing *Overshot*, *Undershot*, and *Breast Wheels*.

Physical Apparatus. Cheapest Set of Physical Apparatus for use in Elementary Schools. Prof. Balfour Stewart's set of apparatus, described in his Science Primer, No. III.

Description of Apparatus.

No. of Experiment.
1, 2.—Tin pan, with peas.
3.—Iron plate with four strings.
4.—Balance to carry 2 lbs. in each scale; beam two feet long.
Piece of metal weighing 200 grains.
Set of weights, 600 grains to ½ grain.
5.—2 lbs. mercury in a bottle.
Two pieces of glass two inches square.
6.—Apparatus unnecessary.
9, 10.—Beam of wood.
Two 4-lb. weights.
15.—Plumb-line.
Stoneware dish for mercury.
16.—Tube for showing level of water.
17.—Metal cylinder with two tubes and stoppers.
Tube with movable bottom and cord.
Water-jar for tube.
Indigo solution.
18, 19.—Substance weighing 1,000 grains, same specific gravity as water.

No. of
Experiment.
20.—Hollow brass cylinder.
Bucket to contain it.
Apparatus for attaching the bucket to balance.
21.—See Experiment 18.
22.—Block to illustrate Flotation.
24.—Apparatus unnecessary.
25.—Tate's Air-pump.
Bell-jar receiver.
Two india-rubber balls.
26.—Jar with neck and flange.
Two pieces of india-rubber for it.
27, 28, 29.—Box with strings.
30.—Magdeburg hemispheres.
Brass cock for hemispheres.
31.—Tube for barometer.
Glass mortar for cistern.
Funnel for filling barometer.
33.—Vibrating wire on support.
37.—Model thermometer.
Centigrade thermometer.
38.—Bladder two-thirds filled with air.
39.—Further apparatus unnecessary.
40.—Use tin pan of experiment 1.
41.—Use flask of experiment 42.
42.—Flask for boiling water, and cork in duplicate.
Triangle and wire gauze to support flask.
43, 44.—No special apparatus necessary.
45.—Pan to hold sulphuric acid *in vacuo*, and shallow vessel to hold water.
46.—No apparatus necessary.
47.—Use flask of experiment 42.
48.—Wires to show unequal power of iron and copper to conduct heat.
50.—Use tin pan of experiment 1.
51.—Apparatus to show image of candle.
52.—Apparatus unnecessary.
54.—Electric pendulum.
Several pieces of elder-pith.
55.—Electroscope.
Electrical machine, 16-inch plate.
Box of amalgam.
56.—Rod, half brass, half glass.
Rod of glass covered with red wax.
Piece of silk.
Piece of flannel.
57.—No additional apparatus.
58, 59.—Brass ball, with point, on insulated stand.
60.—No apparatus required.
61.—Leyden jar, pint size.
Discharger.
62.—Groves battery, 4 cells in frame.
Yard of fine platinum wire.
63.—Voltameter.
64.—Electro-magnet.
65.—Knitting-needle and thread.
66.—Apparatus for Oested's experiment.
67.—Thirty feet of covered wire.

Mechanics.

Black Rail to suspend the models from the school board.
Lever for suspension.
Lever supported on a fulcrum.
Intermittent Motion, model to explain.
Lock and Key, large working model of.
Compound Wheel and *Axle.*
Tilt Hammer.
Screw, model to explain the action of.
Train of *Wheels,* transmission of motion.
Inclined Plane and *Roller.*
Sets of Pulleys :—
 Four simple pulleys.
 Pair of long three-sheave pulleys.
 Pair of square three-sheave pulleys.
 Pair of White's concentric pulleys.
Centre of Gravity :—
 Irregular board to explain centre of gravity.
 Leaning tower to explain centre of gravity.
 Parallelopipeds, a pair of, to explain centre of gravity.
 Double cone running uphill, to explain centre of gravity.
 Bowl-about, a toy to explain centre of gravity.
 Equilibrist, a toy to explain centre of gravity.
 Apparatus to explain *Inertia.*
 Plumb-line and *Mercury Mirror.*
 Pendulums made of various substances.
 Model of a *Vernier.*
 Whirling Table of iron, with set of adjuncts, to explain the action of *Centrifugal Force.*
 Centrifugal Railway, model of.
 Gyroscope for *explaining Inertia.*
 Wedge, model, explaining action of.
 Percussion Machine for experiments on the *collision* of *elastic bodies.*
Constructive Mechanics :—
 Tenon and *Mortice.*
 Scarfing.
 Half Lapping.
 Dove-tailing.

Frictional Electricity.

School Electrical Machine with 18-inch glass plate.

Small, Cheap, Cylinder Electrical Machine.

Conical Conductors to show accumulation of electricity near the point.

Cylindrical Conductors to exhibit and explain *induction.*

Set of *three small and simple Conductors, Ball Cylinder* and *Cone,* for Elementary Schools.

Leyden Jar with movable coats to exhibit the separation of the positive and negative electricity. 1. The glass jar. 2. The inner coat. 3. The outer coat.

Unit Leyden Jar to measure strength of a charge.

Set of *Leyden Jars* for obtaining powerful effects.

Biot's Ball and insulated covers to show that the electricity is only on the surface.

Roll of *Tin Foil* to show effect of increasing surface.

Insulated Stool on which to place a boy as a conductor.

Henley's Universal Discharger for passing charges through an insulated body.

Hand Discharger with insulated handle.

Luminous Flash to show discharge in vacuo.

Cheap Electroscope of large size for lectures, a wooden lath supported on a flask.

Set of *Bells* to be rung by the electrical discharge.

Pith Balls to dance under an excited beaker.

Cheap Conductor, a tea-tray supported by a beaker.

Pith Ball Electroscope.

Gold Leaf Electroscope with condensers.

Gold Leaf Electroscope without condensers.

Vulcanite Electrophorus which gives off sparks when excited by friction.

Glass Rod half roughened to show the two kinds of electricity.

Rod of Sealing Wax for excitation.

Rod of Vulcanite for excitation.

Rod of Shellac for excitation.

Rod of Sulphur for excitation.

Fox's Brush for exciting electricity.

Cats' Skin for exciting electricity.

Pneumatics.

Air-Pump, double barrelled, arranged for rapid action, with an auxiliary *Tate's air-pump* to obtain a very perfect vacuum.

Tate's School Air-Pump; this produces a good vacuum quickly, and is made at a moderate price.

Exhausting and *Condensing Syringe.*

Leslie's Apparatus for *freezing Water* over sulphuric acid in vacuo.

Apparatus to show that a *Guinea* and a *Feather* fall in vacuo with the same velocity.

French Tube Form of *Guinea and Feather Apparatus.*

Apparatus to explain the *Barometer* and the pressure of the atmosphere.

Apparatus to cut an apple in half, by the downward pressure of the atmosphere.

Apparatus to prove that *combustion* cannot take place in *vacuo.*

Heavy Lead Weight which is raised by the expansion of some air contained in a bladder.

Magdeburg Hemispheres for showing that the pressure of the atmosphere is about 15 lbs. on the square inch.

Mercury Cup, in which the pressure of the air forces mercury through the pores of wood.

Marriotte's Apparatus, to show that under the pressure of two atmospheres, air is compressed into half its ordinary bulk.

Marriotte's Apparatus, for experiments under the pressure of half an atmosphere.

Lead Weight supported by the upward pressure of the air.

Fountain in Vacuo, the water being forced up by atmospheric pressure.

Series of Globes to raise water by the alternate expansion and compression of air.

Apparatus showing *expansion* and *compression* of air.

Rubber Balls which expand and contract under varying pressure.

Diving Bell, working model of.

Pair of Water Bottles, the expansion of the air forces the water from one bottle into the other, and the pressure of the atmosphere causes its return.

Tantalus Cup.

Water Hammer, to be exhausted by the air-pump.

Water Hammer; fall of water in a partial vacuum.

Wollaston's Cryophorus, to freeze water by effects of evaporation.

Sound.

Sonometer or *Monochord*, simple form with violin bow.

Sonometer or *Monochord*, superior construction, with violin bow, for experiments on vibrating wires.

Savart's toothed wheels, for use with whirling table, to produce tones.

Paper Disc, perforated, to act as a *Syren*.

Syren, simple, without counter, can be worked by a cheap rubber foot blower.

Syren, with *counter*, can be worked by a cheap rubber foot blower.

Organ Pipe, with *resonance box*.

Resonance Box, with movable piston to explain effect of *length* of *air column*.

Pair of *Lecturer's Tuning Forks*, in *Unison*.

Chladni's Vibrating Plates, a set of three, in brass, with bow, to show figures of vibration.

Chladni's Vibrating Plates, a set of ten in glass, with bow and clamp to hold them.

Hopkins' Forked Tube, to exhibit *interference*.

Speaking Trumpet, model of.

Hydrogen Flame, which *sings* when burning in the glass tube.

Common Gas Jet, which *sings* when burning in the glass tube.

Sound Waves, *propagation* of, apparatus to explain.

Heat.

Fergusson's Pyrometer, to show *unequal expansion* of various metals.

Compound Bar of iron and copper, which bends when heated, to explain effects of *unequal expansion*.

Set of Bulb Tubes, to exhibit the *unequal expansion* of different liquids.

Bar of Iron and Copper, to explain *unequal conduction* of heat.

Ingenhouz's Apparatus, to show *unequal conducting powers* of various substances.

Cylinders of *various metals*, proving the *unequal conducting powers* of metals, and their capacities for heat.

Apparatus to *break* an *iron bar* by *contraction* of heated bar.

Unequal Absorption, by bright and dull surfaces.

Reflectors, pair of silvered copper, for concentrating rays.

Leslie's Cubes, to explain effects of different surfaces in *radiation*.

Leslie's Differential Thermometer, cheap form.

Count Rumford's Differential Thermometer, improved by Matthieson and Griffin.

Metal Tube, in which water can be *boiled* by the *friction* of wooden boards.

Wollaston's Steam Engine, glass model of, showing *expansion* and *condensation* of steam.

Iron Bottles, very thick, which *burst* when water is *frozen* in them.

Hope's Apparatus, to show when *water* reaches its *maximum density*.

Pulse Glass, showing *expansion* of spirit vapour under *diminished pressure*.

Prince Rupert's Drops, unannealed glass, showing effect of *unequal contraction*.

Candle Bombs, containing spirit, the expansion of which causes explosion.

Dr. Tyndall's Apparatus to show water boiling at a lower temperature under a reduced atmospheric pressure.

Balls, of various metals, which pass through a wax plate in times varying as their *capacities* for *heat*.

Faraday's Apparatus, to exhibit *convection* in liquids.

Convection of *Heat* in liquids; large size, for the lecture table.

Set of Barometer Tubes, to show *elastic force* of various vapours.

Marcet's Steam Boiler, to prove that *temperature* increases with *pressure*.

Ventilation of Rooms, fitted bottle, to explain.

Rain Gauge, simple, to measure fall of rain.

Light.

Electric Lamp, source of light.

Groves Battery, to work *electric lamp*.

Perforated Screen, for supporting objects in the ray of light.

Bottle Prism, for holding *carbon sulphide* and producing long *spectrum* on the screen.

Condensing Lens, to throw enlarged images on the screen or wall.

Ground-Glass Screen, to receive small images.

Oxyhydrogen Gas Burner, as source of light.

Oxyspirit Burner, and lantern, cheap substitute for electric lamp.

Complementary Prisms of *Crown and Flint Glass*.

Oscillating Prism, to produce *white light* by rapid action on the retina.

Bunsen and Kirchoff's Spectroscope, for *Spectrum Analysis*.

Set of Lenses, to explain their shape and action.

Set of Lenses, mounted, with focussing screen to explain their various action.

Glass Mirror, concave, to *concentrate* rays.

Glass Mirror convex, to *disperse* rays.

Curved Mirror, showing *distorted* image.

Plane Mirror, black.

Angular Mirrors, double reflection.

Bunsen's Photometer, to *measure* lighting power of gas, &c.

Ritchie's Photometer, for *comparing* one light power with another.

Colour Disc, to explain *constitution* of *white light*.

Colour Disc, with series of discs, explaining *combinations* of *colour*.

Colour Top, explaining *combinations* of *colour*.

Norremberg's Polariscope, showing colours through plates of *mica*, *selenite*, &c.

Tourmaline Tongs, showing *polarised* light, in colours, through crystals.

Newton's Coloured Rings, *retardation* of velocity of rays. *Interference.*

Camera Obscura.

Screens, dull and bright, to explain *absorption* and *reflection*.

Refraction; a line or stick appears bent when partly immersed in water.

Müller's Apparatus, to show *refraction* in water.

Stereoscope angle of vision.

Revolving Disc, to show rapidity of light rays.

Fluorescence, Uranium-Glass Cube, to produce.

Fluorescence, Permanganate of Potash, to produce.

Fluorescence, Uranium Plate, to produce.

Double Refraction, Iceland Spa, to exhibit.

Water-Bulb Microscope.

4092e. Educational Collection. *W. and A. K. Johnston.*

12-inch Terrestrial Globe.
Map of New York, Pennsylvania, &c.
Illustrations of Natural Philosophy; sheet 7—steam engines and book.
Illustrations of Astronomy; sheet 1—solar system and book.
Geological Map of the British Isles, and book.

Physiology No. 1, Illustration No. 5, and book.

Properties of Bodies, Illustration No. 1, and book.

Hydrostatics, Illustration No. 3, and handbook.

Physiology No. 2, Illustration No. 6, and book.

Astronomy, sheet 2, Illustration No. 13, and book.

Astronomy, sheet 3, Illustration No. 14, and book.

Mechanical Powers, Illustration No. 2, and book.

Hydraulics, Illustration No. 4, and book.

Case's Map of the United States.

4092e. Educational Collection. *M. Berthelot, Paris.*

Calorimeter for thermo-chemistry, with agitator.
Electric motor for same.
Glass beaker with lip.
Porcelain dish for quicksilver.
Glass apparatus with spiral tube.
Bottle of alcohol.
Two flasks containing fluid.
Large glass apparatus.
Two bent glass electric tubes.
Glass apparatus with spiral tube at top.
Test tube.
Large bent glass tube containing mercury.
Five tubes containing chemicals.
Glass tube or vacuum glass.
Bent glass tube with wire cloth cup at one end.
Small stoppered bottle of formiate of lead.
Thermometer with scale on iron stand with brass base.
Two glass jars.

APPARATUS FOR TEACHING CHEMISTRY.

4093. Working Bench for a **Chemical Laboratory,** for the use of science classes (according to Dr. R. Arendt).
Franz Hugershoff, Leipzig.

4094. Hofmann's Electrolytic Apparatus.
Ch. F. Geissler & Son, Berlin.

4095. Hofmann's Apparatus for liquefying sulphurous anhydride. *Ch. F. Geissler & Son, Berlin.*

4096. Geissler's Apparatus for determining the greatest density of water. *Ch. F. Geissler & Son, Berlin.*

4097. Hofmann's Electrolytic Apparatus for decomposing hydrochloric acid. *Julius Schober, Berlin.*

4098. Hofmann's Apparatus for showing that in the **Synthesis** of **Ammonia Gas** three volumes of hydrogen unite with one volume of nitrogen, to form two volumes of ammonia gas. *Julius Schober, Berlin.*

4099. Hofmann's Apparatus for showing that in the **Synthesis** of **Water** two volumes of hydrogen unite with one volume of oxygen, to form two volumes of water, gas, or steam.
Julius Schober, Berlin.

4100. Hofmann's Steam Generator, for the lecture-room table. *E. A. Lentz, Berlin.*

4101. Hofmann's Apparatus for decomposing **Phosphuretted Hydrogen.** *Julius Schober, Berlin.*

4102. Distilling Apparatus, for the use of science classes. *F. A. Wolff & Sons, Heilbronn and Vienna.*

This distillation apparatus has been specially constructed at a very cheap rate for the use of science classes, to illustrate distilling operations.

4103. Diagram, showing elevation, section, and plan of a working-bench in the Laboratory of the Strasburg University. *Chemical Institution of Strasburg University.*

4104. Photographs of a portion of the principal room of the **Laboratory** belonging to the Berggewerkschaft Association of Miners at Bochum. *Berggewerkschaftskasse, Bochum, Rhenish Prussia.*

4105. Hofmann's Apparatus for showing the **simultaneous Decomposition** of hydrochloric acid, of water, and of ammonia. *Julius Schober, Berlin.*

4106. Hofmann's Apparatus for showing the **Constancy of the Proportions** in the combination of hydrochloric acid gas with water. *Julius Schober, Berlin.*

4107. Hofmann's Apparatus for showing the **Synthesis** of **Water.** *Julius Schober, Berlin.*

4108. Hofmann's Lecture Room Eudiometer. *Julius Schober, Berlin.*

4109. Hofmann's Apparatus for demonstrating that the volumes of oxygen which enter into the composition of carbon and sulphur dioxide are equal to the respective gas volumes of these compound gases. *Julius Schober, Berlin.*

4110. Hofmann's Apparatus for illustrating the **Phenomena** of **Combustion.** *Julius Schober, Berlin.*

4111. Models from Mitscherlich's **Chemico-technical Collection,** representing—

(1.) A puddling furnace.
(2.) A coke oven.
(3.) The lower part of a blast furnace.

Prof. A. Mitscherlich, Münden.

2604. Warmbrunn, Quilitz, and Co.'s Large Glass Gas Holder, described by R. Müncke in Dingler's Polyt. Journ., vol. 218, p. 40. *Warmbrunn, Quilitz, & Co., Berlin.*

2605. Warmbrunn, Quilitz, and Co.'s Large Copper Gas Holder, of bright metal.
Warmbrunn, Quilitz, & Co., Berlin.

2606. Warmbrunn, Quilitz, and Co.'s Large Copper Gas Holder, bronzed, with top water-reservoir.
Warmbrunn, Quilitz, & Co., Berlin.

2607. Warmbrunn, Quilitz, and Co.'s Copper Water Oven, two-walled, with thermostat, thermometer, and side-tube, showing level of water. *Warmbrunn, Quilitz, & Co., Berlin.*

Described by R. Müncke in Dingler's Polyt. Journ., vol. 219, p. 72.

2608. Water Oven, the same as the above, but made of **Zinc.** *Warmbrunn, Quilitz, & Co., Berlin.*

2609. Warmbrunn, Quilitz, and Co.'s Copper Drying-Closet, single-walled, provided with thermostat and a thermometer. *Warmbrunn, Quilitz, & Co., Berlin.*

2610. Bunsen's Universal Clamp and **Stand,** made of iron, lackered, complete. *Warmbrunn, Quilitz, & Co., Berlin.*

2611. Warmbrunn, Quilitz, and Co.'s Large Universal Clamp and **Stand,** square rods made of brass, square foot-plate of iron and stands, complete.
Warmbrunn, Quilitz, & Co., Berlin.

A description of this apparatus by R. Müncke will be found in Ber. d. Deutsch. chem. Ges. Berlin, 1873, p. 435.

2612. Warmbrunn, Quilitz, and Co.'s Large Universal Stand, with a large double holder, round rods made of brass, and square iron foot-plate, complete (described as above).
Warmbrunn, Quilitz, & Co., Berlin.

2613. Stand of iron, resting on an iron foot-plate, with three two-holed frames or ring-holders, vertical and horizontal ("Doppelmuffen"), rings of three different sizes with straight rods for sliding through the horizontal hole of the frame, binding screws, &c. *Warmbrunn, Quilitz, & Co., Berlin.*

2614. Stand made of brass, with iron foot-plate, five two-holed frames, three large rings of different sizes, two clamps of varying size, all made of brass. *Warmbrunn, Quilitz, & Co., Berlin.*

2615. Brass Stand, on an iron tripod, with two simple brass burette holders. *Warmbrunn, Quilitz, & Co., Berlin.*

2616. Brass Stand, on an iron tripod, with four brass burette holders. *Warmbrunn, Quilitz, & Co., Berlin.*

2617. Liebig's Condenser, in **Glass,** supported by a brass stand on an iron tripod. *Warmbrunn, Quilitz, & Co., Berlin.*

2618. Bunsen Burners (two), of simple construction.
Warmbrunn, Quilitz, & Co., Berlin.

2619. Bunsen Burners, with star, chimney, and reduction-cone. *Warmbrunn, Quilitz, & Co., Berlin.*

2620. Gas Lamps (two), with arrangement for the simultaneous regulation of gas and air, of simple construction.
Warmbrunn, Quilitz, & Co., Berlin.

2621. Gas Lamps, with star, chimney, and reduction-cone.
Warmbrunn, Quilitz, & Co., Berlin.

2622. Two-burner Bunsen Lamp.
Warmbrunn, Quilitz, & Co., Berlin.

2623. Three-burner Bunsen Lamp, with arrangement for the simultaneous adjustment of air and gas.
Warmbrunn, Quilitz, & Co., Berlin.

2624. Five-burner Bunsen Lamp, of similar construction.
Warmbrunn, Quilitz, & Co., Berlin.

2625. Six-burner Bunsen Lamp.
Warmbrunn, Quilitz, & Co., Berlin.

2626. Warmbrunn, Quilitz, and Co.'s Universal Burner, of newest construction, complete.
Warmbrunn, Quilitz, & Co., Berlin.

A description of this burner by R. Müncke, will be found in Ber. d. Deutsch. chem. Ges. 1874, p. 284; in Dingl. Polyt. Journ., vol. 212, p. 141; and in Fres. Zeitsch. f. anal. Chem., XIII., p. 46.

2627. Warmbrunn, Quilitz, and Co.'s Combustion Furnace, with a four-burner gas lamp, complete.
Warmbrunn, Quilitz, & Co., Berlin.

For a description of this furnace by R. Müncke, refer to Dingler's Polyt. Journ., vol. 212, p. 315, and to Fres. Zeitschr. f. anal. Chem., XIII., p. 167.

2628. Warmbrunn, Quilitz, and Co.'s Combustion Furnace, with 12 burners, each provided with simultaneous regulation for gas and air, complete.
Warmbrunn, Quilitz, & Co., Berlin.

2629. Gas-washing Apparatus (comp. R. Müncke, Fres. Zeitsch. f. anal. Chem. XV., Part I.) Three different sizes.
Warmbrunn, Quilitz, & Co., Berlin.

2630. Hydrofluoric Acid Apparatus, consisting of retort, still-head, and U tube, for condensing the acid.
Warmbrunn, Quilitz, & Co., Berlin.

2631. Hydrofluoric Acid Apparatus, consisting of retort, still-head, and receivers, on a stand.
Warmbrunn, Quilitz, & Co Berlin.

2632. Bardeleben's Gas Evolution Apparatus for laboratories; consisting of a large cylinder with bell-glass, and glass vessel with ground brass-plate and bayonet-joint, gas washing apparatus, &c. Quite new.
Warmbrunn, Quilitz, & Co., Berlin.

2633. Pulse Pump, mounted, with reservoir, manometer, two glass stop-cocks, and unions for connecting with the water supply pipe. *Warmbrunn, Quilitz, & Co., Berlin.*

2634. Kipp's Gas Generator, provided with a Geissler glass stop-cock. *Warmbrunn, Quilitz, & Co., Berlin.*

2635. Set of Beakers, without lip, 16 in the set, up to 680 mm. *Warmbrunn, Quilitz, & Co., Berlin.*

2636. Set of Beakers, not lipped, No. $\frac{1-16}{1}$, $\frac{1-12}{1}$, $\frac{1-8}{1}$, $\frac{1-5}{1}$ set. *Warmbrunn, Quilitz, & Co., Berlin.*

2637. Sets of Beakers, lipped, No. $\frac{1-12}{1}$, $\frac{1-8}{1}$, $\frac{1-5}{1}$ set.
Warmbrunn, Quilitz, & Co., Berlin.

2638. Series of Funnels, 10 pieces, from 30 to 130 mm. diameter. *Warmbrunn, Quilitz, & Co., Berlin.*

2639. Series of Lettered (etched) **Reagent Bottles,** 27 pieces. *Warmbrunn, Quilitz, & Co., Berlin.*

2640. Series of Lettered (etched) **Wash Bottles,** for water, alcohol, and ether. *Warmbrunn, Quilitz, & Co., Berlin.*

2641. Graduated Cylinders, of 1,000, 500, 250, and 100 cc.
Warmbrunn, Quilitz, & Co., Berlin.

2642. Graduated Flasks, of $\frac{1}{4}$, $\frac{1}{2}$, and one litre.
Warmbrunn, Quilitz, & Co., Berlin.

2643. Glass-stoppered Burettes, four, of 20 cc. in tenths, 50 cc. in fifths, 50 cc. in tenths, 60 cc. in fifths.
Warmbrunn, Quilitz, & Co., Berlin.

2644. Series of Preparation Glasses for holding liquids, 1–8. *Warmbrunn, Quilitz, & Co., Berlin.*

2645. Series of Preparation Glasses for holding solids, 1–8. *Warmbrunn, Quilitz, & Co., Berlin.*

2646. Series of Flasks, 11 from 30–4,000 cc.
Warmbrunn, Quilitz, & Co., Berlin.

2647. Set of Glass Evaporating Dishes, tipped, 12 pieces, from 55–270 mm. *Warmbrunn, Quilitz, & Co., Berlin.*

2648. Set of Clock Glasses, for evaporating, from 25–315 mm. diam. *Warmbrunn, Quilitz, & Co., Berlin.*

2649. Glass Condenser, consisting of three equal-sized bell-glasses connected by ground necks, holding about 2,000 cc. *Warmbrunn, Quilitz, & Co., Berlin.*

2650. Drying Apparatus, with glass stop-cock. *Warmbrunn, Quilitz, & Co., Berlin.*

2651. Exhaustion Apparatus, in glass, of two litres capacity. *Warmbrunn, Quilitz, & Co., Berlin.*

2652. Bottle, for keeping mercury over acids. *Warmbrunn, Quilitz, & Co., Berlin.*

2653. Levigation Apparatus, with four tubes. *Warmbrunn, Quilitz, & Co., Berlin.*

2654. Air-pump Receiver, with tubulures and glass stop-cock, 280 mm. in height and 200 mm. in diam. *Warmbrunn, Quilitz, & Co., Berlin.*

2655. Aspirator, consisting of a double tubulated Woulff's bottle and ground in glass stop-cock for the lower tube. *Warmbrunn, Quilitz, & Co., Berlin.*

2656. Glass Stop-cock, 330 mm. in length. *Warmbrunn, Quilitz, & Co., Berlin.*

2657. Vinegar Stop-cock, 190 mm. *Warmbrunn, Quilitz, & Co., Berlin.*

2658. Glass Jar, for mercury, provided with glass stop-cock. *Warmbrunn, Quilitz, & Co., Berlin.*

2659. Finkener's Gas Evolution Apparatus, quite new. *Warmbrunn, Quilitz, & Co., Berlin.*

2599. Copper Water Bath, nickel-plated, together with a tripod stand and rings of porcelain as well as metal, and provided with an arrangement for keeping the water at a constant level. *Warmbrunn, Quilitz, & Co., Berlin.*

2600. Copper Water Bath, together with a tripod stand, and an arrangement for keeping the water at a constant level, a set of copper rings, and also a cover with different sized openings. *Warmbrunn, Quilitz, & Co., Berlin.*

2601. Carmichael's Suction Funnel, with improvements. *Chemical Laboratory of the University of Göttingen (Prof. Hübner).*

4112. Hofmann's Apparatus (No. 1–16).

Warmbrunn, Quilitz, & Co., Berlin.

(1.) Apparatus for the electrolysis of hydrochloric acid, of water, and ammonia.

(2.) Apparatus for illustrating the synthesis of hydrochloric acid.

(3.) Apparatus for showing that hydrogen and chlorine when united suffer no contraction of volume.

(4.) Apparatus for showing that two volumes of water-gas (steam) are formed when two volumes of hydrogen unite with one volume of oxygen.

(5.) Apparatus for showing that ammonia consists of three volumes of hydrogen and one volume of nitrogen.

(6.) Apparatus for the simultaneous electrolysis of water, hydrochloric acid, and ammonia.

(7.) Apparatus for showing that the composition of hydrochloric acid does not vary.

(8.) Apparatus for showing that hydrogen and oxygen unite with each other only in the proportions in which they are obtained by the electrolysis of water.

(9.) Apparatus for illustrating the deportment of simple and compound gases under the influence of changes of temperature and pressure. Of novel construction.

(10.) Eudiometer for the lecture-room table with stand.

(11.) Apparatus for experimenting with liquid sulphurous acid.

(12.) Apparatus for illustrating the phenomena of combustion.

(13.) Vapour density apparatus complete.

(14.) Apparatus for proving that the volumes of carbonic and sulphurous anhydride equal the volumes of oxygen which enter into them.

(15.) Apparatus for the electrolysis of phosphide of hydrogen.

(16.) Sodium apparatus.

4113. Series of small **Apparatus,** for illustrating in the lecture room projections on a screen by means of Duboscq's lamp. Manufactured by Dr. Geissler of Bonn.

Prof. H. Landolt, Aix-la-Chapelle.

The series consists of:—

(1.) An apparatus for showing the decomposition of water by the galvanic current.

(2.) Apparatus for decomposing water by means of palladium electrodes with absorption of the hydrogen gas.

(3.) Apparatus for the electrolysis of saline solutions.

(4.) Lecture room eudiometer.

(5.) Apparatus for showing the formation of nitric peroxide by passing electric sparks through air.

(6.) Apparatus for showing the action of oxygen upon nitric acid.

(7.) Apparatus for illustrating the absorption of gases by liquids.

(8.) Condenser for bromine and other coloured vapours.

(9.) Apparatus for showing the formation of flowers of sulphur.

(10.) Apparatus for illustrating the manufacture of sulphuric acid, and for showing the decolorising action of sulphurous acid upon nitric peroxide.

4114. Photographs, illustrative of the chemical lecture-room of the Polytechnic School of Aix-la-Chapelle, and of the contrivances for throwing experimental illustrations on a screen by means of a Duboscq's lamp. *Prof. H. Landolt, Aix-la-Chapelle.*

4115. Photographs of the lecture-room table, showing the provisions made for enabling the audience to see more favourably any experimental demonstration, by employing screens behind the lecture-table. *Prof. H. Landolt, Aix-la-Chapelle.*

APPARATUS FOR TEACHING MINERALOGY.

4116. "Student's Elementary Collection of Minerals." *J. R. Gregory.*

4117. Elementary Collections (four) **of Minerals, Fossils, and Rocks,** systematically arranged, in polished wood cabinets; fitted for the use of the student and science-class teacher, and illustrating the various mineralogical and geological handbooks. *Thomas J. Downing.*

4118. Minerals (24) **for Blowpipe Analysis.** In case, for the pocket. Set I. *Thomas J. Downing.*

4119. Minerals (24) **for Blowpipe Analysis.** In case, for the pocket. Set II. *Thomas J. Downing.*

4127. Apparatus for demonstrating the physical properties of **Steam** and the **Steam-jet.**

Dr. L. Bleekrode, The Hague, Holland.

This apparatus is designed for the lecture-table, and consists in a copper boiler, which is heated by a common gas-burner with six or seven flames. The quantity of water it contains is sufficient to perform all the experiments during an hour, so that it needs no feeding, and the strength of the material permits the production of steam at a pressure of four to five atmospheres.

The following experiments may successively be taken or illustrated one after another:—

I. The principle of the water-gauge in a boiler.

II. The action of the safety-valve.

III. The relation between the tension of vapour and its temperature.
IV. The boiling of water at a pressure higher than the atmosphere.
V. The latent heat of steam and the warming system with steam.
VI. The form of the steam-jet and its property of extinguishing fire. (Here either the vertical or the horizontal valve may be used to lead the steam on to some burning material.)
VII. The producing of a vacuum by the steam-jet. (A metallic box may easily be filled with the escaping steam, and as the box is afterwards shut, it is depressed by the atmosphere.)
VIII. The Giffard's injector. (A glass model is fixed to the horizontal valve.)
IX. The steam producing sound, illustrating the steam-signal and fog-signals.
X. The steam sand blast. (This interesting experiment is performed in a very simple and yet satisfactory manner, by allowing the sand falling through a vertical funnel to mix with the horizontal escaping steam-jet, at the mouth of the valve.)
XI. The electrical properties of the steam-jet. (Armstrong's hydro-electric machine.)
XII. Heat producing work. (Principle of thermo-dynamics.) (Here a model steam-engine is connected with the horizontal steam valve.)

The chief advantages of this apparatus (already used in several institutions in Holland and Germany) are—

1. It allows, with very little expenditure of time and heat, the illustration of the fundamental principles of heat on the lecture table.

2. It produces steam of high pressure, the properties of which may be shown with very little danger.

3. The relatively small expense (10*l.*) renders possible the introduction of this apparatus into schools where physics and mechanics form an importan part of the system of education.

MISCELLANEOUS.

4192a. Cosmographic Apparatus for teaching purposes.
Letellier, France.

4193. Stativ (stand), with a fixed and a movable pulley, besides string and counter-weight.

4194. Polyspast, to be appended to the same stand, with four pulleys, string, and counter-weight.

4195. Lever Apparatus, with attached needle (for the balance) and stand.

4196. Twenty-one **Weights** belonging to the foregoing objects.
Royal Prussian Chief Mining Department, Breslau.

4197. Oscillating Machine (centrifugal apparatus), with the following auxiliary apparatus :—

a. Two-fold brass ring with iron axle.
b. Glass globe with axle.
c. Glass cylinder with inserted Sieboglinder (centrifuge).
d. Double pendulum regulator with throttle-valve.
e. Two balls, joined to each other by a chain.
f. Balancing ruler with sliding weights.

Royal Prussian Chief Mining Department, Breslau.

4198. Model of a Suction Pump.
Royal Prussian Chief Mining Department, Breslau.

4199. Model of a Fire Engine (force pump).
Royal Prussian Chief Mining Department, Breslau.

4200. Four Optical Lenses, with stands, and a round **Paper-Screen,** with stand.
Royal Prussian Chief Mining Department, Breslau.

4201. Optical Prism.
Royal Prussian Chief Mining Department, Breslau.

4202. Steel Magnet.
Royal Prussian Chief Mining Department, Breslau.

4203. Two Magnetic Needles, with stands.
Royal Prussian Chief Mining Department, Breslau.

4204. Galvanic Cell, for potassium bichromate.
Royal Prussian Chief Mining Department, Breslau.

4205. Electro-Magnet, with anchor and stand.
Royal Prussian Chief Mining Department, Breslau.

4206. Electrophor, with cover and glass rod.
Royal Prussian Chief Mining Department, Breslau.

4207. Small Induction Apparatus.
Royal Prussian Chief Mining Department, Breslau.

4208. Small Electro-Magnetical Keyboard and Chiming-work, with paper-roll and marking pencil; a primitive telegraph model.
Royal Prussian Chief Mining Department, Breslau.

4209. Air-Pump, with oblique barrel.
Royal Prussian Chief Mining Department, Breslau.

4210. Pair of Magdeburg Hemispheres.
Royal Prussian Chief Mining Department, Breslau.

4211. Fall Tube.
Royal Prussian Chief Mining Department, Breslau.

4212. Two Glass Globes for Air-Pump.
Royal Prussian Chief Mining Department, Breslau.

4213. Mercury Granulation Apparatus, with glass cylinder. *Royal Prussian Chief Mining Department, Breslau.*

4214. Heron's Ball, with glass bowl.
Royal Prussian Chief Mining Department, Breslau.

4215. Freezing Apparatus, brass stand with glass tubes.
Royal Prussian Chief Mining Department, Breslau.

4216. Syphon Apparatus.
Royal Prussian Chief Mining Department, Breslau.

4217. Expansion Apparatus.

Royal Prussian Chief Mining Department, Breslau.

4218. School Microscope, from the Optical Institute of F. W. Schick, Berlin, with two eyepieces and three object-glasses.

Royal Prussian Chief Mining Department, Breslau.

4219. Collection of Forty Microscopical Preparations from the Institute of Rodig, Hamburg, with explanations by Prof. Dr. Ferd. Cohn.

Royal Prussian Chief Mining Department, Breslau.

The collection serves, in connexion with other means of illustration, for the purpose of teaching in the elementary public schools of the Silesian mining districts the rudiments of the physical and mechanical sciences, and thus to prepare the children of miners for their probable future employment as miners, engine attendants, &c. It is worthy of remark that the money required for the acquisition of these collections, as indeed for the founding of the appropriate schools, comes from a special fund, which owes its origin and continued maintenance to some clauses in the older German mining laws, according to which the revenues of certain mines are applied to school and church purposes. Through the rapid growth and development of the Silesian mining industry, this fund has risen to the value of 25,000*l.* per annum.

The above-mentioned schools are not to be mistaken for the mining schools proper, or the schools serving as preparatory institutions to these latter, both of which are intended for grown-up pupils.

4219a. Apparatus employed in **teaching,** for exhibiting the action of **Electric Currents** on **Currents** of **Magnetism.**

W. Gloukhoff, Warden of Russian Standard Measures.

In this apparatus the mode of suspension of the movable conductors is entirely new, and consists of a brass tube *A, B, C, D,* through which passes an insulated brass wire *E, F*; the wire and the tube have on their tops the metallic cups *E* and *D,* filled with mercury. Into the cup *E* the steel point of suspension and one end of the movable conductor are plunged, and into the cup *D* the other end.

4220. Universal Rotation Apparatus with Twenty-six Auxiliary Apparatus, viz.:—

1. Centrifugal pendulum.
2. Spheres of different weight.
3. Globe, 100 grammes in weight, movable horizontally, with spring balance, on which the centrifugal force can be directly measured.
4. Two oblique glass-tubes for different kinds of liquids.
5. Glass-balloon.
6. Apparatus for demonstrating the flat spherical form of the earth.
7. Apparatus for flattening of an oil-globule (Ring of Saturn).
8. Ring, chain, ball, cylinder, suspended on a cord.
9. Ball, suspended on a long string, for Foucault's pendulum experiment.
10. Glass-balloon for demonstrating the rising of fluids.

11. Model of a centrifugal blast.

12. Model of a draining and drying apparatus.

13. Apparatus by Coulomb, for causing water to boil by friction.

14. Syren-disc, playing one accord.

15. Savart's toothed wheels.

16. Disc with mirror surfaces and flame-manometer for acoustic flame-images.

17. Stroboscopic cylinder for demonstrating various oscillations according to Quincke.

18. Colour-discs.

19. Oscillating prism.

20. Glass-balloon for producing Newton's colour-rings in thin metal plates of fluid.

21. Stroboscopical discs on the systems of Dove, Poggendorff, &c., illuminated by Geissler's tubes.

22. Becquerel's phosphoroscope.

23. Three rotatory tubes by Geissler.

24. Apparatus for Arago's rotation magnetism.

25. Apparatus for producing inducted currents in a rotating copper disc, with electro-magnet.

26. Large wire-spirals for the phenomenon of the earth's induction. *Emil Stöhrer, Leipsic.*

495. Rack and Snail of Clock, to regulate the number of blows struck each hour. *The Council of King's College, London.*

496. Model of Chronometer Escapement.
The Council of King's College, London.

497. Model of Lever Escapement.
The Council of King's College, London.

498. Model of Horizontal Escapement.
The Council of King's College, London.

499. Model of Locking Plate of Clock, to regulate the number of blows struck each hour.
The Council of King's College, London.

4220a. Murby's Photo-lithographed Wall Maps (physical).

World.
British Isles.
Europe.
Central Europe.
Asia.
Africa.
North America.
South „
Palestine.

Thomas Murby.

4220b. Diagrams of Natural History (20).
Thomas Murby.

FIRST SERIES.—APPARATUS FOR SUPERIOR EDUCATIONAL INSTITUTES.

Kinematics, Statics, and Dynamics.

4221. Model of a Bramah's Hydraulic Press.

4222. Model of a Turbine.

4223. Model of a Centrifugal Pump.

4224. Apparatus for demonstrating the **Archimedean Principle,** consisting of hollow brass floater, glass cylinder with discharge tube, and graduated glass cylinder.

4225. Five different Models of Valves.

4226. Inclined Plane.

4227. Gyroscope, according to Fessel.

4228. Gridiron Pendulum.

4229. Bevelled Gearing.

4230. Windlass, with tooth and movement.

4231. Endless Screw.

4232. Centrifugal Machine.

4233. Apparatus for demonstrating **Foucault's Pendulum Experiments.**

4234. Ball-Regulator.

4235. Apparatus for Oblique Tubes.

4236. Glass Vessel for Liquids of different specific weights.

4237. Syren Disc of brass, sounding major and minor chords.

4238. Apparatus for demonstrating the **oblate form of the Earth.**

4239. Colour Disc.

4240. Apparatus, consisting of two balls of unequal weight moving along a wire.

4241. Apparatus, consisting of a ball sliding on a wire and lifting various weights. *E. Leybold's Successors, Cologne.*

Molecular Physics.

4242. Stop-cock Air-Pump, with horizontal cylinder and gauge; can be put in motion by a movement.

4243. Hand Air-pump, with oblique cylinder, and gauge.

4244. Pair of Magdeburg Hemispheres, 105 mm. in diameter.

4245. Mercury Granulation Apparatus.

4246. Apparatus for showing the **equal Pressure of the Air** in all directions.

4247. Windmill-sail Apparatus, for showing the resistance of the air.

4248. Apparatus for explaining the **Aneroid Barometer** and **Spring Manometer.**

E. Leybold's Successors, Cologne.

Heat.

4249. Steam Apparatus, of copper, on supports of brass.

4250. Aeolipile, on stand.

4251. Model of a Steam Engine, with oscillating cylinder.

4252. Rotating Steam Ball.

4253. Apparatus for explaining the effects of **Steam.**

4254. Contraction Apparatus.

4255. Pyrometer, according to Muschenbrock.

4256. Mirror Pyrometer, according to Tyndall.

4257. Apparatus for converting work into heat.

4258. Noë's Thermochain, star form.

E. Leybold's Successors, Cologne.

Magnetism.

4259. Graphite Zinc Element, consisting of graphite plate, clay-cell, and zinc cylinder.

Height of the clay-cell 78 millimeter.
„ „ 104 „
„ „ 130 „
„ „ 156 „
„ „ 208 „
„ „ 260 „

4260. Chromic Acid Element, small, bottle-shaped, with two graphite and one zinc plate.

4261. Chromic Acid Element, larger, with two graphite and one zinc plate.

4262. Chromic Acid Element, with three zinc and one graphite plate.

4263. Coal-light Apparatus, with small reflector (hand regulator).

4264. Water Deposition Apparatus.

4265. Oxy-hydrogen Gas Apparatus, Werner's construction.

4266. Constant Battery, according to Stöhrer.

4267. Twenty pair of Plates.

4268. Tangent-Compass, with movable compass.

4269. Horizontal Galvanometer, box-shaped.

4270. Multiplicator, according to Schweigger, for thermo-electrical currents.

4271. Table Galvanometer.

4272. Electro-Magnet, arranged for a table, and for suspension.

4273. Apparatus for showing the rotation of a magnet.

4274. Apparatus for showing the rotation of two magnets, caused by a current.

4275. Magnet, rotating around its own axis.

4276. Electro-Magnetical Oscillating Apparatus, with supporter for Geissler's tubes.

4277. Electro-Magnet, rotating under the influence of terrestrial magnetism.

4278. Electro-Magnet, rotating in a second, with contrivance for lifting weights.

4279. Machine, according to Page.

4280. Electro-Magnet rotating above a steel magnet.

4281. Barlow's Wheel.

4282. Lightning Wheel, according to Neef.

4283. Apparatus, according to Petrina, showing the attraction of parallel currents.

4284. Ampère's Frame, according to Eisenlohr.

4285. Model of Morse's Writing Telegraph.

4286. Induction Apparatus, according to Dubois-Reymond, arranged for medical purposes.

4287. Pocket Induction Apparatus, according to Werners.

4288. Spark Inductor, according to Ruhmkorff.

4289. Spark Inductor, according to Ruhmkorff.

4290. Induction Apparatus for fundamental experiments.

4291. Steel Magnet, with five thin plates and keeper.

4292. Dipping Needle, with stand.

4293. Magneto-electrical Induction Apparatus.

4294. Blasting Apparatus for **Mining.**
E. Leybold's Successors, Cologne.

Electricity.

4295. Electrical Machine, according to Winter, with different connexions for the condenser.

4296. Holtz's Induction Machine. Diameter of the rotating wheel 520 mm.

4297. Chime with five bells.

4298. Fly-wheel on a circular track.

4299. Lanne's Measure Bottle.

4300. Discharging Rod.

4301. Double Fly-wheel.

4302. Battery of four Leyden Jars.

4303. Pair of fine Gold-leaf Electrometers.

4304. Pair of fine Gold-leaf Electrometers, with **Zamboni's Column,** improved according to Fechner.
E Leybold's Successors, Cologne.

SECOND SERIES.—APPARATUS AND INSTRUMENTS FOR ELEMENTARY SCHOOLS.

Kinematics, Statics, and Dynamics.

4305. Inclined Plane, simple.

4306. Windlass (Göpel).

4307. Rod Windlass.

4308. Wooden Screws, with threads of different section.

4309. Wheel on Axle, with stand.

4310. Reel, with stand.

4311. Six Lever Apparatus, for demonstrating different laws of leverage.

4312. Apparatus for illustrating the action of pulleys.

4313. Glass Model of a Suction and Forcing Pump.

4314. Glass Model of an Hydraulic Press.

4315. Glass Model of a Fire Engine.

4316. Segner's Water-wheel.

4317. Model of a Diving Bell.

4318. Apparatus for illustrating the **Expansion** and **Compression of Air.**

4319. Fly-wheel of glass.

4320. Fly-wheel.

4321. Rotating Suction Siphon.

4322. Apparatus for demonstrating the uniform transmission of pressure in liquids.

4323. Model of a Suction-pump.

E. Leybold's Successors, Cologne.

Molecular Physics.

4324. Hand Air-pump.

4325. Pair of Magdeburg Hemispheres.

4326. Scale Manometer.

4327. Sound Apparatus, for weighing air.

4328. Apparatus for illustrating that a vacuum can be filled by a liquid through atmospheric pressure.

4329. Apparatus for demonstrating that bodies of unequal weight fall at the same rate in vacuo.

4330. Barometer.

E. Leybold's Successors, Cologne.

Light.

4331. Prism.

4332. Astronomical Models, illustrating course of the rays of light.

E. Leybold's Successors, Cologne.

Heat.

4333. Apparatus, glass, for demonstrating the **Effect of Steam.**

4334. Apparatus, globe, and ring, for demonstrating the expansion of metals by heat.

E. Leybold's Successors, Cologne.

Magnetism.

4335. Simple Diving Element.

4336. Double Diving Element.

4337. Galvanoplastical Apparatus.

4338. Pair of Carbon Points, with handles.

4339. Apparatus for making **Wires red hot.**

4340. Water Decomposition Apparatus.

4341. Electro-magnet, with two binding screws.

4342. Electro-magnetical Driving Machine.

4343. Induction Apparatus, for extra current and secondary current.

4344. Bar Magnets.

4345. Horse Shoe Magnet.

E. Leybold's Successors, Cologne.

Electricity.

4346. Simple Electrical Machine.

4347. Electrical Tuft.

4348. Simple Gold-leaf Electrometer.

4349. Fundamental Apparatus, according to Werners, for friction electricity, magnetism, and galvanism.

4350. Electrophorus, 210 mm. in diameter.

4351. Electrical Shower of Balls.

4352. Electrical Pistol.

4353. Electrical Discharging Rod.

4354. Simple Chime of Bells.

4355. Leyden Jar, 156 mm. high.

4356. Isolating Stool.

E. Leybold's Successors, Cologne.

THIRD SERIES.—APPARATUS AND APPLIANCES FOR TEACHING CHEMISTRY.

Chemistry.

4357. Series of **Reagent Jars,** with enamelled labels and inscriptions.

4358. Carbonic Acid Apparatus, according to Bunsen.

4359. Potash Apparatus, according to Liebig.

4360. Potash Apparatus, according to Mohr.

4361. Potash Apparatus, according to Mitscherlich.

4362. Sulphuretted Hydrogen Apparatus.

4363. Drying Apparatus, by means of sulphuric acid.

4364. Combustion Stove, according to Bunsen, with 25 burners.

4365. Combustion Stove, according to Glaser, with 20 burners.

4366. Set of 12 Bohemian Glass Beakers.

4367. Set of 6 Bohemian Glass Beakers.

4368. Bellows, with lamp, for glass-blowing.

4369. Burette, according to Bink's, 50 cc. in $\frac{1}{5}$.

4370. Burette, according to Gay-Lussac, 50 cc. in $\frac{1}{10}$.

4371. Porcelain Burette Stand, with eight burettes (dropping glasses).

4372. Glass Burette, according to Geissler, 50 cc. in $\frac{1}{5}$.

4373. Burette, with porcelain stand.

4374. Burette, with stand of polished wood.

4375. Combination Cylinder, according to Mohr, 1,000 c.

4376. Dephlegmator, according to Staedler.

4377. Azotometer, according to Knop, modified by Wagner.

4378. Filtering Frame, of iron, with leaden base.

4379. Filtering Frame, of brass, with wooden base.

4380. Universal Stand, according to Werners.

4381. Set of 9 Evaporating Dishes, of enamelled iron.

4382. One Litre **Clarifying Bottle,** with glass and stopper.

4383. Series of 8 **Boiling Jars,** according to Erltenmeyer.

4384. Cooling Apparatus, glass.

4385. Set of 7 **Cork Borers,** in brass.

4386. Bunsen Burner, with stand.

4387. Seven Burette-holders, three rings, chimney, retort.
4388. „ „ with regulator.
4389. „ „ with regulator and stop-cock.
4390. „ „ with three pipes.
4391. „ „ with seven pipes.
4392. „ „ with twelve pipes and tripod.

4393. Gas Stove, with seven burners and stop-cock.

4394. Three Glowing Lamps, according to Masté.

4395. Blow-pipe Case.

4396. Pipette Stand, of polished wood; porcelain stand.

4397. Polished Revolving Reagent Bottle Frame, to hold 36 bottles.

4398. Unpolished Reagent Bottle Frame, according to Llandolt's, with 18 bottles.

4399. Crucible Tongs, of brass.

4400. Series of Glass Funnels, Bunsen's shape.

4401. Copper Water-bath, 9-inch.

4402. Copper Water-bath, on tripod.

4403. Constant Level.

E. Leybold's Successors, Cologne.

4404. Hestermann's Technological and Physical Science Apparatus:—

4405. Flax and its applications.

4406. The Cotton Plant and its use.

4407. Wool and its application.

4408. The Honey Bee and its industry.

4409. Leather, its preparation and employment.

4410. Silk, its production and application.

4411. Paper, its manufacture and use.

4412. Glass, its manufacture and employment.

4413. Illuminating and Heating Materials, their production and use.

4414. Dyeing and **Cotton Printing.**

4415. Collection of Products, III. Course.

4416. Iron, its production, manufacture, and use.

4417. Collection of Caterpillars, with text, by Director Dr. Bolan.

4418. Cabinet containing Silkworms.

4419. Forest Herbarium, Parts I. and II.

4420. Herbarium of Poisonous Plants.

4421. Herbarium of Grasses.

Chr. Vetter, formerly Ludw. Hestermann, Hamburg.

Apparatus and Instruments for Chemists and Natural Philosophers.

4423. Chemical Scale for 1 ko. weight, indicating 1 milligr., with special balance and scales, and stopping arrangement; gilt; the scales are of platinum, in glass case; the beam works on agate planes.

4424. Set of Weights belonging to the same, gilt, from 1 ko. downwards.

4425. Two Sets of Weights, from 50·0 grm. downwards, nickel plated.

4426. Sets of Weights of Rock Crystal, from 200·0 gr. downwards.

The weights of 200-100 grammes have a cylindrical form. This form has been chiefly chosen in order that, in case of any neglect, injuries might be avoided as much as possible.

4427. Normal 500·0 gr. Weight, of rock crystal.

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. Herm. Rohrbeck).

Physics.

4428. Single-barelled Air Pump, with standing glass tube, double acting, on wooden stands.

The arrangement of the air pump is such that the position of the stop-cock of the receiver places it alternately in connexion with the upper and the lower part of the cylinder.

The pump is particularly adapted for exhausting a large number of recipients, as is very frequently requisite at scientific experiments in laboratories.

4429. Attwood's Machine, with pendulum.

4430. Gridiron Seconds Pendulum, on stand.

4431. Mack's Galilei's Fall Kennel.

4432. Centrifugal Machine, with auxiliary apparatus.

The construction of the machine is distinguished by its simplicity. The stand, formed by a cast-iron frame, can be set either horizontally or vertically.

4433. Hydraulic Press.

4434. Air Pump, with two glass tubes, and Babinet's stopcock.

With apparatus :—*a.* Barometer test; *b.* Magdeburg hemispheres; *c.* Mercurial granulation; *d.* Globe (recipient); *e.* Electric egg; *f.* Cylinder for bursting of bladders; *g.* Freezing apparatus.

4435. Mach's Wave Apparatus, for illustrating the longitudinal and transversal waves.

4436. Mach's Apparatus for **Sound Reflection.**

4437. Mach's Apparatus for **Refraction and Reflexion.**

4438. Mach's Apparatus for demonstrating the **Law of Refraction** by means of fluorescent liquids.

4439. Mach's Apparatus for demonstrating the **Effects of Lenses.**

4440. Model of a Screw, of wood.

4441. Model of a Screw, of wood.

These two models serve for explaining and illustrating to the student the screw motions. One represents a flat, the other a triangular worm; both serve for demonstrating the longitudinal transverse sections.

4442. Crown Glass Prism.

4443. Flint Glass Prism.

4444. Polyprism.

4445. Hollow Prism.

4446. Universal Kaleidophon, for illustrating Lissajou's figures.

This consists of a thin strip of copper, sliding on a wooden clamp, which may be fastened by a screw to the table, and can be raised to any height desired.

On the upper part of this strip of copper there is attached a second clamp, through which passes a band of steel terminating at the top in a brad. By means of this second clamp the steel band can likewise be fixed at any desired height. If by pulling with the finger the strip of copper, and in a perpendicular level to the same, the steel band is set into oscillation, these two movements will combine into one, which, according as the respective longitudinal relations of the two strips are altered will be different. By the brad attached to the upper part of the apparatus these movements can be clearly observed, and Lissajou's figures demonstrated.

4447. Meyerstein's Heliostat.

4448. Astronomical Telescope, on a wooden stand with scale.

4449. Pocket Spectroscope, according to Professor Emsmann, with only *one* prism, and contrivance for specially placing the separate colours.

4450. Another Specimen of the same kind.

4451. Thermo-electrical Battery, according to Clamond.

This consists of 40 elements, which are arranged in four groups, which can be placed either side by side or one after the other. The heating of the soldered places takes place from the centre by gas, but not *directly*, however, by heated air generated in the interior of the battery. The gas turns from small holes made round a clay cylinder. For an equal supply of gas, particularly in order to avoid at a stronger pressure an excessive heating of the soldered places, an ordinary gas regulator with floats, as is customary with gas meters, has been attached. If the supply of gas increases the valve closes, opening again at the decrease of pressure. As, consequently, the supply of gas regulates itself in this way, the column uninterruptedly acts for weeks and months, while its current is extremely constant at an effective force of 5 cc. oxygen and hydrogen gas a minute, and is therefore particularly adapted for the quantitative separation ofmetals from solutions.

As regards the durability of the apparatus, it may be remarked that after 18 months daily use, no perceptible alteration has been noticed.

4452. Thermo-electrical Battery, according to Noë.

This differs from the previous one,—

1, by the arrangement of the metals, which in this case are grouped in two horizontal rows, in the centre of which (and this is the second essential difference) a number of burners heat the soldered places *directly*. The cooling of the other soldered places is, as in the previous battery, simply atmospheric, for which purposes, in order to render it as perfect as possible, copper plates are connected with the other soldered places, so that a constant current of air passes through the same.

The number of elements is 88, grouped into 8 elements, which by means of a very handy pachytrope can be intercalated in different manner.

4453. Lane's Measure-bottle, fine adjustment, with scale and vernier.

4454. Separable Leyden Jar.

4455. Electroscope, after Professor Mach, for demonstrating that electricity lies on the surface of excited bodies.

4456. Holtz's Electrical Machine.
Auxiliary apparatus:—*a.* Lightning-tube. *b.* Lightning-plate. *c.* Chime of bells. *d.* Dancing dolls. *e.* Contrivance for breaking glass plates. *f.* Henley's discharging rod. *g.* Discharging rod, with joint.

4457. Pair of Concave Mirrors, brass, 16 inch diameter, 8 inch focal distance, on tripods, with contrivance for adjustment and equipment for heat experiments.

4458. Two Sectional Models of Steam-engines.

4459. Model of a Screw Steamer.

4460. Lever Pyrometer.

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. H. Rohrbeck).

Chemistry.

4461. Plattner's Assay-balance, for blow-pipe purposes, in mahogany case, with 1 gr. weight, indicating $\frac{1}{10}$ milligr., with weights.

4462. Balance, on stand, according to Wackenroder, to carry 20 gr., and indicating 1 mgr., &c.

4463. Technical Balance, on stand, to carry 500 gr., and indicating 5 mgr.

4464. Mohr's Tare-balance, in mahogany scale case, with brass column, bow-scales, and ebonite plates, to carry 1 kilogramme, and indicating 1 centigr.

4465. Scales, for weighing substances affecting metals, to carry 250 gr., and indicating 5 mgr.

4466. Complete Mohr's Balance, for determining the specific weight of liquid and solid bodies.

4467. Mohr's Balance, with one arm.

4468. *a.* **Exsiccator,** according to Schrötter, consisting of tubulated glass jar on a frosted glass plate, framed in wood, with crucible stand, and chloride of calcium tube.

4469. *b.* **Exsiccator,** according to Fresenius, consisting of glass cylinder, &c.

4470. *c.* **Exsiccator,** according to Fresenius, with frosted glass plate.

4471. *d.* **Exsiccator,** according to Luhme, with porcelain vessel for sulphuric acid, and etagère.

4472. *a.* **Drying Closet,** according to Fresenius, of copper, with two tubes and thermometer.

4473. *b.* **Drying Closet,** according to Fresenius, of copper, with grate, wire net, thermometer, and chloride of calcium tube, for drying pulverised substances.

4474. *c.* **Drying Closet,** according to Rammelsberg, with two tubes and thermometer.

4475. *d.* **Drying Closet,** according to Rose, with double sides, two tubes, and thermometer.

4476. **Drying Disc,** according to Fresenius, for agricultural chemical purposes, with thermometer.

4477. **One Burner** to the same.

4478. **Burner, Blast, and Lamp.**

4479. *a.* **Aeolipile,** of brass plate.

This has a vertical flame for soldering, bending glass, melting, by means of the flame of alcoholic vapour.

They are likewise constructed with horizontal flame of embossed brass or copper with safety-valve, on a stand with lamp.

4480. *b.* **Berzelius' Lamp,** on porcelain plate.

Berzelius lamp on a brass stand on a porcelain plate, consisting of the lamp with spirit reservoir, two rings, and chimney.

4481. *c.* **Lamp,** according to Mitscherlich.

The spirit reservoir of this lamp is separated from the burner by a pipe 230 millimeters in length, and consists of a bottle provided with a conical valve, which is inserted in a reverse way in a brass cylinder, by which means a constant level of the spirit in the lamp has been secured.

4482. *d.* **Simple Burner,** with glass tube.

4483. *e.* **Bunsen's Jet Burner,** uni-radiating, with case for illuminating flame.

4484. *f.* **Bunsen's Burner,** with chimney, and fork-shaped holder.

4485. *g.* **Bunsen's Burner,** with star-ring, chimney, and blow-pipe apparatus.

4486. *h.* **Finkner's Burner,** with gas and air regulator.

4487. *i.* **Finkner's Burner,** with star-ring and chimney.

4488. *k.* **Griffin's Burner.**

4489. *l.* **Burner,** according to the Viennese model.

4490. *m.* **Double-radiating Jet Burner.**

4491. *n.* **Treble-radiating Jet Burner.**

4492. *o.* **Iserlohn Gas-stove Burner,** with one emission ring.

4493. *p.* **Iserlohn Gas-stove Burner,** with double emission ring.

4494. *q.* **Blow-pipe-table Adjustment,** according to Magnus.

4495. *r.* **Blow-pipe-table Adjustment,** with two stop-cocks on stativ, and porcelain plates, according to Rohrbeck.

4496. *s.* **Apel's Stove.**

4497. *t.* **Universal Stand,** of iron, with Finkner's patent burner, four rings, and three retort-holders.

4498. *u.* **Iron Filtering Stand,** with three rings.

4499. *v.* **Schellbach's Retort-holder.**

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. Herm. Rohrbeck).

4500. Professor A. W. Hofmann's Apparatus and Instruments.

a. Apparatus for ascertaining the volume proportions of hydrogen and chlorine, consisting of V-shaped tube, with two glass stop-cocks, and iron stand.

b. Apparatus for proving, that at the formation of the HCl, one volume Cl and one volume H combine; consisting of a glass tube, with two stop-cocks, decomposition apparatus, and two pipe supporters, calcium chloride cylinder, and a vessel for the electrolytical analysis of hydrochloric acid.

c. Water-decomposition apparatus for demonstrating that 2 vol. hydrogen and 1 vol. oxygen are the volume proportions of water; consisting of a triangular tube, with two stop-cocks, and platinum electrode (the tube also graduated); iron stand.

d. Steam-tight apparatus, consisting of one graduated barometer-tube with envelope-pipe, iron stand with holder, measuring apparatus, boiling and cooling vessel and serpentine-pipe.

e. Apparatus for ascertaining the volume proportions of nitrogen and hydrogen in ammonia; consisting of tube with stop-cock and stopper, a glass cylinder, movable table, and glass bowl.

f. Apparatus for ascertaining the volume proportions of the elementary constituents of HCl, H_2O, and NH_3, by electrolytical means; consisting of two glass apparatus with coal-electrodes, a water-decomposition apparatus with platinum electrodes, and three iron stands.

*f*¹. Apparatus for proving that at the combination of the respective elementary gases HCl, H_2O, and NH_3, always two vol. gas are formed; consisting of three V-shaped tubes with platinum electrodes, and three iron stands.

g. Apparatus for demonstrating that the gases H and Cl combine in the constant proportion of 1 : 1 into hydrochloric acid; consisting of a glass tube with stop-cock, and two ground-in stoppers, with stand.

h. Apparatus for the decomposition of nitric acid; consisting of a little platinum piston, a stand, a funnel-tube with stop-cock, a pneumatic trough, and a cylinder.

i. Apparatus for domonstrating the equal volume proportions of simple and compound gases; consisting of steam apparatus, steam-conducting pipe, glass apparatus with five stop-cocks, and an iron stand.

k. Apparatus for making experiments with sulphurous acid.

l. Apparatus for the decomposition of hydrogen phosphide; consisting of V-shaped tube with two electrodes, and a stand.

m. Apparatus for showing the capability of oxidisation and reduction of the gas flame; consisting of a copper crucible, with tripod and gas-burner.

n. Apparatus for the electrolytical decomposition of the HCl, H_2O, and NH_3; consisting of V-shaped tube with platinum electrodes, and iron stands.

o. Reagent étagère for bottles; with octagonal stopper, ribbon-label, etched inscription, and formula on the stoppers.

4501. Apparatus for demonstrating the Valency of Atoms, according to Kekulé.

Consisting of a number of differently coloured balls for demonstrating the importance of the elements and the origin of the combination of the elements, on an iron stand.

4502. *a*. **Cooler of Zinc,** after Liebig, on stand.

4503. *b*. **Cooler of Brass,** after Liebig.

4504. *c*. **Cooler of Glass,** according to Hofmann.

4505. *a* **Two Agate Mortars,** with pestle, 65, 150 mm. diameter.

4506. *b*. **Three Glass Mortars,** with pestle, 60, 100, 120 mm. diameter.

4507. *c*. **Three Powder Mortars,** of porcelain, with pestle.

4508. *d*. **Pill Mortar of Iron,** 155 mm. diam.

4509. *e*. **Diamond Mortar.**

Diamond mortars for facilitating the pulverisation of minerals difficult to triturate, a process absolutely necessary in making quantitative analysis.

4510. *e^1*. **Diamond Mortar.**

4511. *f.* **Caustic Potash Form,** of iron, 12 channels.

4512. *a.* **Filtering Pump,** according to Bunsen.

For filtration under high pressure with barometer scale and regulating cock screwed on sheet iron.

4513. *b.* **Pump,** according to Liebig, for drying organic substances.

A small hand air pump with screw for fastening the same to the table.

4514. Alkalimetrical Apparatus.

4515. *a.* **Burette Stand,** with eight movable burettes.

4516. *b.* **Four graduated Cylinders,** 250·0, 500·0, 1000·0, 3000·0 cc.

4517. *c.* **Mixing Bottle** (cylinder), 1000 cc.

4518. *d.* **Measuring Piston,** two litres.

4519. *e.* **Measuring Piston,** one litre with stopper.

4520. *f.* **Carbonic Acid Apparatus,** according to Oechelhäuser.

For determining the per-centage of small quantities of carbonic acid contained in coal-gas, by means of the absorption of potash-lye.

4521. *g.* **Carbonic Acid Apparatus,** according to Rüdorff.

4522. *h.* **Carbonic Acid Apparatus,** according to Scheibler.

4523. Glass Gasometer, with brass fittings for use in chemical laboratories.

4524. Three different polished Retort-holders.

4525. Four different Blow-pipes.

These are of brass, nickel silver with veneered or inlaid platinum plates, as well as arranged for direct use with gas.

4526. Two crucible Pincers of steel and nickel silver.

4527. One Dozen Funnels.

4528. One Dozen Boiling Jars.

4529. One Dozen Pistons.

4530. Six Sets of Glass Bowls.

4531. One Dozen of Woulff's Jars.

4532. One Dozen Retorts.

4533. Six Glass Stop-Cocks.

4534. Six Separation Funnels.

4535. Six Potash Apparatus.

4536. Sulphuretted Hydrogen Apparatus, according to Kipp, with ground in glass cock.

4537. Displacement Apparatus, according to Robiquet, with funnel provided with ground in glass stopper.

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. Herm. Rohrbeck).

Glass wool, very convenient for filtering acids and alkalies in place of asbestos, much cleaner, and practical. If washed after use, it can be employed various times.

Technology.

4538. Wooden Model of a Blast Furnace.

4544. Wooden Model for demonstrating the Manufacture of Sulphuric Acid.

4545. Wooden Model of a Glass Furnace (Siemens' regenerative system).

All these wooden models can be conveniently taken asunder, for demonstrating the interior arrangement of the stoves.

4539. Wooden Model of a Shaft Furnace.

4540. Wooden Model of a Puddling Furnace.

4541. Wooden Model of a Rolling and Stamping Mill.

4542. Wooden Model of a Silver-Ore Refining Furnace.

4543. Wooden Model of a Double Roasting-Furnace for Copper.

W. J. Rohrbeck, J. F. Luhme & Co., Berlin (Dr. Herm. Rohrbeck).

4546. Apparatus for the graphical demonstration of the **Law** of **Descent.**

4547. Apparatus for determining the **Linear Expansion** by **Heat,** by means of reading by mirror reflection.

4548. Müller's Wave Disc.

(*a.*) Stativ (stand).
(*b.*) Portfolio with stroboscopical discs.

4549. Some **Drawings** which Müller used, in the years 1840 and 1850, in his lectures explanatory of apparatus.

Physical Institute of the University of Freiburg, Baden (Prof. Dr. A. Claus).

Glass Models of the Eye (3.)

Science Schools, South Kensington Museum.

SECTION 20.—MISCELLANEOUS.

West Gallery, Upper Floor, Room (O).

PORTRAITS AND RELICS.

4572. Sir Isaac Newton. Portrait engraved by J. Outrim. From the original drawing in the Pepysian Collection at Cambridge. *Robert James Mann, M.D.*

4572a. Photographic Copy of an early portrait of **Galileo.** *J. Norman Lockyer, F.R.S.*

BOOKS.

4573. The Works of Van Marum, and the three volumes already issued of the Archives du Musée Teyler.
Teyler Foundation, Haarlem.

For illustration of the instruments that are shown, and in order to give an idea of the great electrical machine and the chemical apparatus which could not be transported, the works of Van Marum "Machine Electrique" (three volumes), and "Appareils Chimiques" (one volume), containing the engravings of that instrument, are sent.

The three volumes of the "Archives du Musée Teyler" contain the refractive indices and wave-lengths determined by Prof. Van der Willigen; the chemical composition of various specimens of crown and flint-glass by the late Prof. Van Kerckhoff; the description and drawings, by Conservator Dr. Winkler, of fossil tortoises, and other palæontological objects, &c.

4573a. Biography of Don Francisco Salva y Campillo, and an account of his studies and inventions upon electric telegraphs. By Don Antonio Suaver Saavedra.
MS. original. 4to.
Direccion General de Correos y Telegrafos, Madrid.

Don Salva, who lived at Barcelona at the end of the last century, devoted most of his time to making observations and experiments upon electric telegraphs. He published several memoirs on this subject, which are of great interest.

4573a. Studies on Electricity by Don Francisco Salva.
Academia de Cuncias Naturales Yartes de Barcelona, Spain.

"Memoria sobre la electricidad aplicada a la telegrafia."
"Disertacion sobre el galvanismo."
"Memoria sobre el galvanismo aplicado a la telegrafia."

These studies on electricity were written by Don Francisco Salva in 1795 to 1804.

Pamphlet in 4to. Barcelona, 1876.

4573b. Report of the Royal School of Mines upon the apparatus sent to this exhibition to determine the right lineal conduction of a given point, invented by the pupil of the same School of Mines, Sr. Bentibol y Vreta. MS. pamphlet, 4to.

H. Bentabol y Vreta Royal School of Mines, Madrid.

4574. Manuals and Treatises on method of instruction of all branches of Natural History, adopted by the military schools in Russia. Published by Fenoult.

Committee of the Pedagogical Museum, Russia.

331a. Pamphlet. "Procedimientos mecanicos de cubicacion." 4to. Madrid, 1876. *Don Eduardo Saavedra, Madrid.*

Sr. Saavedra explains in this pamphlet the method adopted by him in taking out quantities for the projected railroads of the central Spanish Pyrenees.

4574a. List of Publications.

Messrs. Macmillan and Co., London.

Count Rumford's works, with memoir. 5 vols.

Works by Sir G. B. Airy, M.A., LL.D., D.C.L., Astronomer Royal, &c.—Treatise on the algebraical and numerical theory of errors of observation, and the combinations of observations.—Popular astronomy.—On Sound and Atmospheric Vibrations.

Reuleaux's Kinematics of Machinery. Translated by Prof. A. B. Kennedy.

Experimental Mechanics. By R. S. Ball, M.A.

The Beginnings of Life. By H. Charlton Bastian, M.D., F.R.S. 2 vols.

Rudiments of physical geography for the use of Indian schools, and a glossary of the technical terms employed. By Henry F. Blandford, F.G.S.

First principles of chemical philosophy. By Josiah P. Cooke, junior, Ervine Professor of Chemistry and Mineralogy in Harvard College.

Cave Hunting. Researches on the evidence of Caves, respecting the early inhabitants of Europe. By W. Boyd Dawkins, F.R.S., Director of the Museum and Lecturer on Geology in Owen's College, Manchester.

An introduction to the Osteology of the Mammalia. Being the substance of the Course of Lectures delivered at the Royal College of Surgeons of England in 1870. By W. N. Flower, F.R.S., F.R.C.S., Hunterian Professor of Comparative Anatomy and Physiology.

Pharmacographia. A history of the principal drugs of vegetable origin found in commerce in Great Britain and British India. By F. A. Flückiger and D. Hanbury, F.R.S.

The Elements of Embryology. By Michael Foster, M.D., F.R.S. and F. M. Balfour, M.A., Fellow of Trinity College, Cambridge.

Meteorographia, or Methods of Mapping the Weather. By Francis Galton, F.R.S.

Hereditary Genius; an Inquiry into its Laws and Consequences. By Francis Galton, F.R.S.

English Men of Science, their Nature and Nurture. By Francis Galton, F.R.S.

Works by Hugh Godfray, M.A.—An Elementary Treatise on the Lunar Theory, with a brief Sketch of the Problem up to the time of Newton.—A Treatise on Astronomy, for the use of Colleges and Schools.

The Forces of Nature. A popular Introduction to the Study of Physical Phenomena. By Amédée Guillemin. Translated from the French by Mrs.

Norman Lockyer; and edited with Additions and Notes, by J. Norman Lockyer, F.R.S.

The Student's Flora of the British Islands. By J. D. Hooker, C.B., F.R.S., M.D., D.C.L., President of the Royal Society.

A Treatise on Ornamental and Building Stones of Great Britain and Foreign Countries. Arranged according to their Geological Distribution and Mineral Character, with illustrations of their application in Ancient and Modern Structures. By Edward Hull, M.A., F.R.S., Director of the Geological Survey of Ireland, &c.

Lessons in Elementary Physiology. By T. H. Huxley, LL.D., F.R.S., Professor of Natural History in the Royal School of Mines.—Lay Sermons, Addresses, and Reviews. By the same.

A Course of Practical Instruction in Elementary Biology. By T. H. Huxley, LL.D., Sec. R.S., assisted by H. N. Martin, B.A., M.B., D.Sc. Fellow of Christ's College, Cambridge.

Elementary Lessons in Logic: Deductive and Inductive. With copious Questions and Examples, and a Vocabulary of Logical Terms. By W. Stanley Jevons, M.A., F.R.S., Professor of Logic in Owen's College, Manchester.

The Principles of Science. A Treatise on Logic and Scientific Method. 2 vols. By W. Stanley Jevons, M.A., F.R.S., Professor of Logic in Owen's College, Manchester.

The Owen's College Junior Course of Practical Chemistry. By Francis Jones, Chemical Master in the Grammar School, Manchester. With Preface by Professor Roscoe.

Journal of Anatomy and Physiology. Conducted by Professors Humphry and Newton, and Mr. Clark of Cambridge, Professor Turner of Edinburgh, and Dr. Wright of Dublin. Vols. 8 and 9.

Introduction to Quaternions, with Numerous Examples. By P. Kelland, M.A., F.R.S., and P. G. Tait, M.A., Professor in the Department of Mathematics in the University of Edinburgh.

Researches on the Solar Spectrum and the Spectra of the Chemical Elements. By G. Kirchoff, of Heidelberg. Translated by Henry E. Roscoe, F.R.S.

By J. Norman Lockyer, F.R.S. Elementary Lessons in Astronomy.—Contributions to Solar Physics.

The Romance of Astronomy. By R. Kalley Miller, M.A., Fellow and Assistant Tutor of St. Peter's College, Cambridge.

Lessons in Elementary Anatomy. By St. George Mivart, F.R.S.

Nature Series.

The Spectroscope and its Applications. By J. Norman Lockyer, F.R.S.

The Origin and Metamorphoses of Insects. By Sir John Lubbock, M.P., F.R.S.

The Birth of Chemistry. By G. F. Rodwell, F.R.S., F.R.A.S.

The Transit of Venus. By G. Forbes, B.A., Professor of Natural Philosophy in the Andersonian University, Glasgow.

The Common Frog. By St. George Mivart, F.R.S.

Polarisation of Light. By W. Spottiswoode, LL.D., F.R.S.

On British Wild Flowers, considered in relation to Insects. By Sir John Lubbock, M.P., F.R.S.

Newton's Principia. Edited by Professor Sir W. Thomson and Professor Blackburn.

Lessons in Elementary Botany. By Daniel Oliver, F.R.S., F.L.S., Professor of Botany in University College, London.

First Book of Indian Botany. By Daniel Oliver, F.R.S., F.L.S., Professor of Botany in University College, London.

On a Method of Predicting, by graphical construction, Occultations of Stars by the Moon and Solar Eclipses for any given place. Together with More Rigorous Methods for the Accurate Calculation of Longitude. By J. C. Penrose, F.R.A.S.

An Elementary Treatise on Steam. By John Perry, Bachelor of Engineering, Whitworth Scholar, &c., late Lecturer in Physics at Clifton College.

Elements of Physical Manipulation. By Edward C. Pickering, Thayer Professor of Physics in the Massachusetts Institute of Technology.

Primers.—Science.

Chemistry. By H. E. Roscoe, F.R.S., Professor of Chemistry in Owen's College, Manchester.

Physics. By Balfour Stewart, F.R.S., Professor of Natural Philosophy in Owen's College, Manchester.

Physical Geography. By A. Geikie, LL.D., F.R.S., Murchison Professor of Geology and Mineralogy in the University of Edinburgh.

Geology. By Professor Geikie, F.R.S.

Physiology. By Michael Foster, M.D., F.R.S.

Astronomy. By J. N. Lockyer, F.R.S.

Botany. By J. D. Hooker, C.B., P.R.S.

The Theory of the Glaciers of Savoy. By M. Le Chanoine Rendu. Translated by A. Wills, Q.C., late President of the Alpine Club. To which are added the Original Memoirs, and Supplementary Articles by Professors P. G. Tait and J. Ruskin. Edited, with Introductory Remarks, by George Forbes, B.A., Professor of Natural Philosophy in the Andersonian University, Glasgow.

A System of Medicine. Vol. I. Edited by J. Russell Reynolds, M.D., F.R.C.P., London. Part. I. General Diseases, or Affections of the whole System. Part II. Local Diseases, or Affections of particular Systems. Vol. II. Part. II. Diseases of the Nervous System. (*a.*) General Nervous Diseases. *b.*) Partial Diseases of the Nervous System. I. Diseases of the Head. II. Diseases of the Spinal Column. III. Diseases of the Nerves. II. Diseases of the Digestive System. (*a.*) Diseases of the Stomach. Vol. III. § II. Diseases of the Digestive System (continued). (*b.*) Diseases of the Mouth. (*c.*) Diseases of the Fauces, Pharynx, and Œsophagus. (*d.*) Diseases of the Intestines. (*e.*) Diseases of the Peritoneum. (*f.*) Diseases of the Liver. (*g.*) Diseases of the Pancreas. § III. Diseases of the Respiratory Organs. (*a.*) Diseases of the Larynx. (*b.*) Diseases of the Thoracic Organs.

Lessons in Elementary Chemistry, Inorganic and Organic. By Henry E. Roscoe, F.R.S., Professor of Chemistry in Owen's College, Manchester.

The Spectrum Analysis. A series of lectures delivered in 1868, with four appendices. Third edition, with the most recent discoveries and additional illustrations. By Henry E. Roscoe, F.R.S., Professor of Chemistry in Owen's College, Manchester.

A Manual of the Chemistry of the Carbon Compounds, or Organic Chemistry. By Schorlemmer, F.R.S.

Lessons in Elementary Physics. By Balfour Stewart, F.R.S., Professor of Natural Philosophy in Owen's College, Manchester.

Recent Advances in Physical Science. By Professor P. G. Tait.

Sound and Music. A Non-mathematical Treatise on the Physical Constitution of Musical Sounds and Harmony, including the chief Acoustical

Discoveries of Professor Helmholtz. By Sedley Taylor, M.A., late Fellow of Trinity College, Cambridge.

Papers on Electrostatics and Magnetism. By Professor Sir W. Thomson, F.R.S.

The Depths of the Sea. By C. Wyville Thomson, LL.D., F.R.S., &c., Director of the Scientific Staff of the "Challenger" Exploring Expedition.

A History of the Mathematical Theories of Attraction and the Figure of the Earth, from the time of Newton to that of Laplace. By Isaac Todhunter, M.A., F.R.S.

Contributions to the Theory of Natural Selection. By Alfred Russell Wallace.

Prehistoric Annals of Scotland. 2 vols. By Daniel Wilson, LL.D., Professor of History and English Literature in University College, Toronto.

Prehistoric Man. 2 vols. By Daniel Wilson, LL.D., Professor of History and English Literature in University College, Toronto.

Wallace's Geographical Distribution of Animals.

4574b. Collection of Scientific Books.

Messrs. Longmans.

Text-books of science :—
    Strength of Materials.
    Inorganic Chemistry.
    Algebra and Trigonometry.
    Organic Chemistry.
    Principles of Mechanics.
    Elements of Mechanism.
    Metals.
    Elements of Geometry.
    Theory of Heat.
    Workshop Appliances.
    Arithmetic and Mensuration.
    Quantitative Chemical Analysis.
    Telegraphy.
    Railway Appliances.
    Electricity and Magnetism.
    Qualitative Chemical Analysis.
Proctor.—The Moon.
Hartley.—Air and its Relation to Light.
Ganot.—Natural Philosophy.
Proctor.—Universe.
Bourne.—The Steam Engine.
Proctor.—Light Science.
Bourne.—Catechism of the Steam Engine.
Proctor.—Saturn, &c.
Helmholtz.—Scientific Lectures.
Butler.—Atlas.
Bourne.—Improvements in the Steam Engine.
Griffin.—Notes on Algebra.
Irving.—Manual of Heat.
Hunter.—Key to Merrifield's Technical Arithmetic.
Watts' Dictionary of Chemistry. (7 vols.)
Dr. Ure's Dictionary of Arts. (3 vols.)
Weinhold's Experimental Physics.
Ganot's Physics. (Atkinson.)
Helmholtz.—The Sensations of Tone.
Crookes.—Handbook of Dyeing.

Bourne.—Steam Engine. (New edition)
Tyndall.—On Sound.
Tyndall.—Heat a Mode of Motion.
Tyndall.—On Light.
Tyndall.—Contributions to Molecular Physics.
Tyndall.—On Magnetism.
Tyndall.—Notes on Light.
Tyndall.—Notes on Electricity.

4574c. Collection of Books.

Messrs. Cassell, Petter, and Galpin.

Davidson.—Educational Series.—Drawing for Carpenters and Joiners; do. Cabinet Makers; do. Machinists; do. Bricklayers; do. Metal Plate Workers; do. Stone Masons; Linear Drawing; Model Drawing; Gothic Stonework; Practical Perspective; Building Construction; Projection; Linear Drawing and Projection.

Ball.—Applied Mechanics.
Church.—Colour.
Ryan.—Systematic Drawing and Shading.

Galbraith & Haughton.—Mathematical Tables; Euclid, Books I.–III.; IV.–VI.; Hydrostatics; Tidal Cards; Manual of Algebra; Plane Trigonometry; Arithmetic; Algebra, Part I.; Steam Engine.

Haughton.—Tides; Mechanics; Optics; Astronomy; Natural Philosophy; The Three Kingdoms of Nature.

Hart.—Elementary Chemistry.
Wallace.—Elements of Algebra.
Cassell's Euclid by Wallace.
Tyndall.—Natural Philosophy.

3417. Magazine of Mathematical Instruments. Part II. upon Reichenbach's Wiederholung's-circle. Part III. upon Breithaupt's Repeating Circle, &c. Part IV. upon Mine Theodolites. Part V. upon Levelling Instruments.

F. W. Breithaupt and Son, Cassel (G. Breithaupt).

PLANS AND DRAWINGS.

4575. Three Plans of Sir Josiah Mason's College of Science at Birmingham. Ground plan, Ground floor, and Second floor.

George Gore, F.R.S.

4576. Collection of Plans and Programmes of Foreign Laboratories, &c. *George Gore, F.R.S.*

1. Das Neue Chemische Laboratorium, zu Berlin, von Albert Cremer. Mit 12 Kupfertafeln. Berlin, Verlag von Ernst D. Korn, 1868.

2. Die Polytechnische Schule zu Aachen, entworfen von Robert Cremer, ausgeführt und herausgegeben von Ferdinand Esser. Mit 11 Kupfertafeln. Berlin, Verlag von Ernst D. Korn, 1871.

3. Das Chemische Laboratorium der Universität Greifswald, von G. Müller. Mit 6 Kupfertafeln. Berlin, Verlag von Ernst D. Korn, 1864.

4. A. M. Kir, Eggetem Vegytani Intézetének Leirasi (öt Táblával), Than Karoly. Pesten, Eggenberger Ferdinand M. Tud. Akad, Köngvárusnál Hoffmann és Molnár, 1872.

5. Das Chemische Laboratorium der K. Ungarischen Universität in Pest, von Dr. Carl von Than. Mit 5 zinkografischen Tafeln. Wien, 1872, Wilhelm Braumüller.

6. Programm der K. K. Technischen Hochschule in Wien, für das Schuljahr 1873–4. Verlag der K. K. Technischen Hochschule von L. W. Seidel & Sohn, Wien, 1873.

7. Das Neue Chemische Laboratorium der Universität Leipzig, von Hermann Kolbe. Mit einen Situationsplan in Lithographie und 7 Holzschnitten. Leipzig, F. A. Brockhaus, 1868.

8. Programm der Polytechnischen Schule zu Aachen für den Cursus 1871–2. Verl. von J. Stercken, Aachen.

9. Das Landwirthschaftliche Studium an der Universität Göttingen, von Gustav Drech. Tler. Mit 4 lithsafeln, Göttingen, 1872. Deuerlichsche Buchhandlung.

10. Über das Physiologische Privat Laboratorium am der Universität Leipzig, von Johann N. Czermak. Mit 5 Holzschnitten, Leipzig. Verlag von Wilhelm Engelmann, 1873.

4576a. Programme of Polytechnic School, Carlsruhe, 1871 (2 copies). *George Gore, F.R.S.*

4576b. Programme of Polytechnic School, Aix-la-Chapelle, 1872. *George Gore, F.R.S.*

4576c. Higher Polytechnic Instruction in Germany, Switzerland, France, Belgium, and England, 1873. By Paul Köristka. *George Gore, F.R.S.*

4576d. Order of Study, Polytechnic School, Carlsruhe, 1869. *George Gore, F.R.S.*

4576e. Polytechnic School, Hanover, 1856. *George Gore, F.R.S.*

4576f. Ground Plan of the University of Leipzig. *George Gore, F.R.S.*

4576g. Personal Register of the University of Leipzig, 1872. *George Gore, F.R.S.*

4577. Plans of Chemical Laboratories at the Owens College, Manchester. *Alfred Waterhouse.*

As will be seen in the plans, the chief features of the building are two large laboratories, each 70 ft. long, 30 ft. broad, and 29 ft. high. No. 1 (Fig. 1.) is devoted to the first year's or qualitative students. In this there are 60 working places. No. 2 (Fig. 1) is arranged for the advanced or quantitative students, and contains ten blocks of four benches, each for the accommodation of 40 students.

The first essential in a laboratory, that of good light, is provided for by large windows and skylights on both sides. The other essential, that of plenty of air and good ventilation, is secured by lofty rooms having cubic contents of upwards of 50,000 ft., and by means of the powerful draught of a high chimney at one end of the laboratory block; the upward current being maintained by means of a furnace in the basement at the foot of the chimney, which furnace in the winter works the hot water heating apparatus, and in the summer simply serves for ventilating purposes.

The ventilation of the laboratory may be divided into two kinds, (*a*) the general ventilation, and (*b*.) the special ventilation. (*a*) The general ventilation is effected by a wooden perforated ceiling running the whole length of both of the main laboratories, and conveying the vitiated air by a large air-trunk to the shaft, within which rises the smoke flue of the furnace. The supply of fresh air is obtained from a high level by a fresh air shaft, down which the air passes, the hot water pipes being drawn by the aspiration of the chimney into the laboratories through gratings placed in the walls. This ventilation acts so successfully, that although no less than 44 beginners are now working in the qualitative (No. 1) laboratory, and 42 advanced students are working in the quantitative (No. 2) laboratory, still the air in both rooms is clear and pleasant throughout the day. In case, through negligence or accident, a large escape of acid fumes should occur, the windows being hung on pivots, can all be opened, and a thorough renewal of the air be effected in a few minutes. (*b*) The special ventilation is also worked by the main shaft, and is divided between the evaporating niches in the walls shown in plan, and in detail in Figs. 13 to 21, and the sulphuretted hydrogen closets marked A in the detailed drawing on each working table. Each of the niches is provided with an upright glazed earthenware pipe, 4 in. in diameter, running into a horizontal pipe of the same material, 12 inches in diameter, communicating directly with the main chimney, the draught in which is powerful enough to draw air from each one of the niches without the necessity of any gas flame being used for aspiration, and no escape is noticed in the working of these when any fumes, even of sulphuric acid, are evaporated in any quantity. In order to prevent the condensation of acid liquors, or of water, when these substances are boiled in the niches, a porcelain funnel is introduced into the lower part of the earthenware pipe inside the niche; all vapours generated under this funnel are immediately swept into the chimney, and no condensation whatever takes place inside the glass windows of the niche. One of these porcelain funnels is placed in the exhibition. The amount of air which in actual practice is found to pass up these draughts, is as follows:—

The large niches at the west end of the laboratory, aspirate 100 cubic ft. of air per minute, and each of the smaller ones in the three walls running east and west, 12 cubic ft. of air per minute.

The sulphuretted hydrogen closets in each working bench, shown in section in Fig. 11, and in plan in Figs. 7 and 9, are joined together in groups of two or four, and placed in connexion with a 7 in. or 4½ in. glazed earthenware pipe communicating with a horizontal flue shown in section in Fig. 5, running between the fireproof arching under the floor, and passing into the chimney at the point (S), Fig. 1. The down draught in each of these closets is continuous and powerful, each closet in the laboratory No. 1 aspirating at the rate of 5 cubic ft. per minute, whilst those in laboratory No. 2 aspirate on an average 20 cubic ft. per minute, those at the furthest end of the laboratory differing but slightly from those situated nearest to the chimney. The details of the arrangements of the working benches are seen in Figs. 6 to 12. The small block of buildings shown in section in Fig. 5, and on plan in Figs. 1, 2, and 3, consists of two floors, each containing seven rooms divided into, on the ground floor, 1, organic analysis room; 2 and 3, balance rooms; 4, gas analysis room; 5, library; 6, Prof. Schorlemmer's lecture theatre for organic chemistry; 7, Prof. Schorlemmer's private room.

The basement floor contains—1, laboratory for medical students, with accommodation for 50 workers, also ventilated by the main shaft; 2, metallurgical laboratory containing furnaces, also in connexion with the large chimney; 3, store room; 4, class room; 5, lavatory and cloak room; 6, spectroscopic room; 7, photographic room; 8, dark room for photometry; 9, boiler house; and 10, preparation rooms.

The first floor, Fig. 2, contains Professor Roscoe's private room, private balance room, and private laboratory with window opening into laboratories Nos. 1 and 2.

It will be seen from the plans that the block of working laboratories communicates by a corridor with the large chemical lecture theatre (capable of seating an audience of 380), which has a small laboratory for the lecturer's immediate use behind his platform.

4577a. Drawings of the Lecture Table in the Theatre of the Royal College of Science, Dublin, erected under the direction of Professor Barrett. *Prof. W. F. Barrett.*

No. 1 represents the front elevation.

The shafting S, S, is divided into two parts, which can be thrown into one by the clutch and handle H, H^1. A belt passes round the large wheel E to a three-cylinder water engine situated under the theatre seats; another belt passes round T to a turbine placed beside the water engine; both engines are surrounded by felt and packing to deaden their sound. Water is admitted to the engines by means of the screw handles E^1 and T^1, thus one or both halves of the shaft can be simultaneously driven. The spindles of E^1 and T^1 pass through the floor to the pipes below; a hinged lid provides access to the cocks below for oiling or repair. This lid, &c. also serves as a sloping foot-board for the lecturer.

Gas is laid on to every part of the table, and by means of the connections and cocks G, G, flexible tubes can be attached. The peculiar construction of these cocks enables them to be turned aside below the table when out of use, or to be turned over the table when in use, thus preventing the kinking of the flexible tubing. A large view of the cock is shown at G, Fig. 4.

Oxygen is laid on to different parts of the table for the oxyhydrogen light, or other purposes. One cock is seen at O near the pneumatic trough, other oxygen cocks are seen at O, O^1, in Fig. 2. The supply is obtained from gasholders in the yard.

Compressed coal gas or hydrogen in like manner is laid on from a gasholder and comes to the table through the pipes and cocks H, H, Fig. 2.

Battery wires are laid on to the switch C, Fig. 1, a large view of which is shown on the small diagram. By turning the handle of the switch from 10 to 50 cells or 1 to 5, can be thrown into circuit; the binding screws for wire attachments are seen at B, B, B.

Water at high and low pressure is laid to the cocks at W', W'', W''', &c.

W is a large cock for screwing on hose, &c.

W' is a cock for filling pails, and by turning it outwards over the sunk sink 2 the water flows, and is shut off by turning it back.

W'' is a small cock for filling small vessels.

W''' is a high pressure screw tap admitting water to a pillar screwed on to W''' in Fig. 2.

W^4 is a cock that turns water on to the pneumatic trough, and W^5 is a screw cock that gives a supply of water to the other end of the table.

A speaking tube P is laid on from the table to the battery and gasholders in the yard.

A, A^1, are *cupboards* below the table, A for the purpose of keeping apparatus dry and warm, A^1 under the pneumatic trough for a battery closet. In

Fig. 5 this cupboard is shown open ; X is a *draught* pipe leading to a flue at the back of the lecture theatre.

In Fig. 5 is also shown the manner of opening the lid of the pneumatic trough ; the slide V rests on the solid brass pillar Y, which is hinged at its upper end to the table.

No. 2 shows the surface of the table.

The pneumatic trough is seen open. X^1 is a down draught pipe to carry off noxious gases.

X^{11} is another down draught at the right hand of the lecturer. These draught holes are closed by round lids, over which is a square well-fitting block. When all the openings are closed the top ef the table presents a solid unbroken surface.

R is a slide that can be removed entirely to allow of free access to the lamp which stands on a swivel table, as shown in Fig. 3.

U, U^1, are brass collars wherein fit, by means of a bayonet joint, sliding brass arms, one of which is shown in Fig. 3.

I is an aperture (that can be closed by the lid I^1) to allow a belt to pass from the shafting on to the table.

Fig. 3 gives a perspective view of the table, with some apparatus placed on it to show the use of some of the fittings.

4578. Plan of the Laboratory of Physics of the Imperial University of St. Petersburg, with an index of its sections. *Imperial University, St. Petersburg.*

In the plan of the room devoted to the experiments of students, there is indicated the arrangement of the several groups of apparatus required for demonstration. A complementary description written separately contains a short sketch of the experimental problems that are successfully laid before the students during their first year's experimental studies.

PHOTOGRAPHS.

4556. Photographs of Scientific Instruments in the Institute of Physical Science, Royal University of Rome.

Director, Prof. Blaserna.

1. Balance of precision made by the mechanician Scateni, of Urbino ; the suspension very simple and excellent. With a weight of kilogram 2 per scale. Indicates to ½ milligramme.

2. Universal wheel, made in the workshop of Galileo, in Florence. It allows rotary motion to be produced in cylinders and discs in horizontal and vertical directions with the most different velocities.

3. Scott's Phonautograph, made by the machinist De Palma, of Naples. The writing lever has a special arrangement devised by Mr. Campbell, lecturer at the Physical Science Institute, by which it rests only upon the centre of the vibrating membrane, while the other support transforms the vibrations into movements parallel to the axis of the rotating cylinder.

4. Instruments of precision, made by Starke and Kaumerer, of Vienna :— (A.) Complete theodolite ; horizontal and vertical circle, which permits, by the aid of microscopes with a movable ocular thread, to read up to 1″. (B.) Apparatus for the measurement of the indices of refraction. For the reading are added two microscopes with movable ocular threads, allowing a direct reading of 1″. Repeating movement, with excellent arrangement of the

plate bearing the prism. (C.) Cathetometer, with movable ocular thread, allowing a reading of $\frac{1}{100}$ millimetres.

5. Magnetic instruments, according to Lamont, made by Dr. Carl, of Munich, Bavaria :—(A.) Theodolite, for the absolute measurement of declination and of the horizontal component. The two microscopes allow the reading of the second. (B.) Instruments to measure the variations of the horizontal component and of the inclination.

6. Differential interruptor, made by Prof. Blaserna, for the study of currents induced and of the extra currents. Full description given in the "Giornale di Scienze Naturali ed Economiche," Palermo, 1870. Sensitive from $\frac{1}{100\cdot000}$ to $\frac{1}{100\cdot000}''$.

7. Electric and magnetic apparatus, for measurement and by projection:—(A.) Quadrant galvanometer, by Dr. Carl, for instruction purposes, with two threads, one thick and short, the other fine and long. (B.) Sine and tangent compasses. (C.) Apparatus of projection, by Prof. Blaserna, for the demonstration of magnetic phenomena, provided with two arresters of the oscillations, one by water and the other of thick brass, for experiments in deviation and oscillation. (D.) Electrometer (Thomson), according to Kirchhoff, for projection. (E.) Wiedemann's compass, with three pairs of spirals by Kipp.

8. Electric apparatus, for measurement and by projection :—(A.) Bifilar electrometer of Palmieri, made by De Palma, of Naples. (B.) Edelmann's compass. (C.) Thomson's galvanometer. (D.) Wheatstone's rheostat.

9. Electric apparatus, for measurement and by projection :—Wheatstone's bridge, made by Stöhrer, of Leipsic, with its commutator, Kipp's rheostat. (B.) Astatic galvanometer, with a very short thread, to show the thermo-electric currents, and currents of terrestrial induction by projection, made by Campbell. (C.) Astatic galvanometer, with a long thread and reflector, made by Ruhmkorff. (D.) Electric multiplier, by Belli.

10. (A.) Perfected Kipp's chronoscope, with apparatus for the fall of weights. (B.) Kipp's chronograph.

4562. Photographs representing various Scientific Instruments in the Cabinet of Geodesy and Hydrometry, Royal University of Padua. *Prof. Legnazzi, Director, Padua.*

Group I.—Telescopes, Squares, and Prisms.

1. Ramsden's Dynamometer, made in the workshops of the Royal Observatory of Padua (1866).
2. Dioptric with pointers by the Giuseppe Stefani, of Padua (1827).
3. Squares with triangular prism, by Ertel, of Monaco (1872).
4. Square of Wollaston, by Merlo, of Milan (1869).
5. Model of telescope for public instruction, designed by Professor Legnazzi, and constructed by Francesco Pasini (1875).
6. Achromatic telescope by the celebrated Geo. Dollond, of London (1740).
7. Telescope with distance-measurer, by Rochon (1828).
8. Land surveying squares, simple, from the workshop of the Royal Observatory of Padua.
9. Heliotrope, by Ertel, of Monaco (1873).
10. Camera Lucida, by the distinguished optician Amici, of Florence (1836).
11. Reflection square from the Tecnomanasio of Milan (1868).
12. Reflection square and allineator, by Goldschmid, of Zurich (1872).
13. Seconds counter, by Ertel, of Monaco (1874).
14. Telescope with distance-measurer, by Rochon (1869).
15. Terrestrial telescope, by the optician Plössl, of Vienna (1845).
16. Pantometer, with compass from the Tecnomanasio of Milan (1864).

17. Ordinary telescope—Cornet.
18. Achromatic terrestrial telescope, by Frescura, of Padua, 1872.
19. Hypsometer from the Tecnomanasio of Milan.
20. Pantometer from the Tecnomanasio of Milan.
21. Studies of the human eye considered as a telescope, made by Professo Legnazzi in Padua (1873).

GROUP II.—GRAPHOMETERS, MULTIPLYING CIRCLES, AND THEODOLITES.

1. Antique graphometer; more than three centuries old; instead of verniers, it is furnished with the diagonal scale designed by Don Pedro Nunnez, and gilt with sequin-gold. The tripod is worthy of observation.
2. English sextant (1798).
3. Ebony sextant with ivory edge, by Shuttleworth, of London (1840).
4. Repeating circle, by Lerebours, of Paris (1832).
5. Reflecting circle, by Baumann, which gives five seconds with telescope (1845).
6. Theodolite of the celebrated mechanician Reichenbach, of Monaco, which gives 10 seconds (1828).
7. Repeating theodolite, by Carlo Starke, constructed in the Imperial and Royal Polytechnic Institute of Vienna; the horizontal circle gives 4″, the vertical 10″. The bubble has a sensibility of 4″ (1852).
8. Multiplying circle, by Reichenbach, of Monaco; a remarkable machine the circle gives 4″ (1832).
9. Multiplying circle, by Gambey, of Paris, which gives 3″ (1822).
10. Repeating theodolite of Troughton and Sims, which gives 10″: a well designed and well constructed machine.
11. Eccentric theodolite, by Ertel, of Monaco, gives 10″; an excellent and most convenient instrument, constructed with great care and elegance (1843).
12. Multiplying circle, by Lenoir, of Paris; is an embryo instrument, but well designed (1836).
13. Theodolite by Nairne and Blunt, of London; besides degrees, the horizontal circle furnishes the tangents of the various angles. With this theodolite the engineer Valle executed the topographical survey of the city of Padua (1828).

GROUP III.—PRÆTORIAN TABLETS.

1. Steel band, length 20 meters, with divisions, constructed in the Tecnomanasio of Milan (1870).
2. Prætorian tablet on the Italian system, constructed by Giuseppe Stefani, of the Royal Observatory of Padua (1833). This is completely mounted to follow the configuration of the ground.
3. Gnomon, for the rotation of the dioptric.
4. Dioptric, with pointers and telescope, by Giuseppe Stefani.
5. Small spherical level from the Tecnomanasio of Milan (1869).
6. Dioptric, with telescope, by Alemanno, of Turin (1870).
7. Small level, with bubble of invariable length, designed by Professor Legnazzi, and constructed by his pupil Francesco Pasini (1875).
8. Small common level of the Italian tablet.
9. Prætorian tablet of the Italian system by Rochetti, of Padua, without the mirror and the accessory instruments in order to show its construction.
10. Small metrical chain of precision, of 10 meters, which was employed in the operations of the measurement of the arc of meridian of France (1802–1817).

11. Topographical compass, by Giuseppe Rodella, of the Royal Observatory of Padua (1795).
12. Prætorian tablet of the German system by Carl Starke, of Vienna, without the mirror, in order to show its construction (1856).
13. Prætorian tablet of German system, by Carl Starke, of Vienna, complete (1842).
14. Small level, by Ertel, of Monaco (1874).
15. Dioptric, with telescope and distance-measurer, by Carl Starke, of Vienna (1852) ; an excellent instrument.
16. Small level of the Starke tablet.
17. Gnomon and compass of the Starke tablet.
18. Dioptric and telescope of the Starke tablet.
19. Metrical chain of 20 mètres.
20. Odometer, by Adams, of London (1791).

Group. IV.—Levels.

1. Aneroid, by J. Goldschmid, of Zurich ; where can be read an eight-thousandth part of a millimètre of movement in the sides of the box (1874).
2. Naudet's olosteric barometer, by Feigestock, of Vienna, which gives the one-tenth of a millimètre of atmospherical pressure (1874).
3. Metallic thermometer of Bourdon.
4. Naudet's olosteric barometer, by Hirsch, of Florence ; gives half a millimètre of pressure (1872).
5. Naudet's olosteric barometer, by Frescura, of Padua (1873).
6. Naudet's olosteric barometer, by Feigestock, of Vienna ; like No. 2.
7. Aneroid barometer, by Bourdon (1859).
8. Aneroid barometer, by Naudet ; like No. 2.
9. Metallic barometer, Bourdon, from the Tecnomanasio of Milan.
10. Olosterical barometer, Naudet, by Feigestock ; like No. 2.
11. Level with telescope, by Rocchetti, of Padua, with thread micrometer (1853).
12. Level with distance measurer, by Carl Starke, of the Imperial and Royal Polytechnic Institute of Vienna (1855) ; an excellent instrument.
13. Pendulum level with two telescopes ; an historical piece ; must be very old ; the telescopes are not achromatic.
14. Level with telescope, by Rodella, of Padua (1820).
15. Level with mirror, rather old.
16. Level with distance measurer, by Starke and Kammerer, of Vienna (1876) ; an exquisite instrument.
17. Pocket level, by Carl Starke, of Vienna (1850).
18. Level with communicating tubes ; an old model (1810).
19. Level, system Egault, with telescope (1861).
20. Bubble, fitted by Rocchetti, of Padua (1844).
21. Barometer, Gay Lussac (1830).
22. Barometer, Fortin, by Rocchetti, of Padua (1850).
23. Water level with telescope ; an historical instrument ; must be at east two centuries and a half old.
24. Ecclimeter, by Rocchetti, which also serves as a level (1847).
25. German Biffa, system Stampfer (1856).
26. Italian Biffa, by Rocchetti, of Padua (1849).
27. Speaking Biffa (1862).
28. Egyptian Biffa (1862).
29. Old Italian Biffa (1812).
30. German Biffa, system Stampfer (1856).
31. Biffa, Milesi (1874).

GROUP V.—PLANIMETERS, COMPASSES, AND INSTRUMENTS OF PRECISION.

1. Octagonal Planimeter, of the Florentine Tito Gonella, by Carl Starke, of Vienna (1852); an exquisite instrument.
2. Three polar planimeters (1) from the Tecnomanasio of Milan; (2) by Amsler-Laffon, of Schafhausen; (3) by Ertel, of Monaco (1869).
3. Planimeter, by Amsler-Laffon, of Schafhausen; a very delicate instrument of recent invention (1873).
4. Tychonic scale, designed by Giuseppe Pavan, of Padua (1874).
5. Box compasses, by Montan, of Padua (1827).
6. Crystal grating, by Merlo, of Milan (1870).
7. Compass fitted by Montan, of Padua (1827).
8. Calculating circle, constructed by Professor Legnazzi (1856).
9. Calculating rule, Gravet-Lenoïr (1860).
10. Crystal grating, at the workshop of the Observatory of Padua (1849).
11. Apparatus to graduate the small levels designed by Professor Legnazzi (1866).
12. Box compass complete, by Toni, of Milan (1853).
13. Box compass, by Bordogna, of Milan, a celebrated maker (1780).
14. Ellipsograph, designed by Prof. Legnazzi, and constructed at the Royal Observatory of Padua in 1870.
15. Compass of precision to take thicknesses.
16. Compass of Bauernfeind, constructed by Mayer, of Dünkelsbühl, which serves for the prætorian tablet (1871).
17. Rule to draw a parallel at a given distance, by Rodella, of Padua (1819).
18. Wide compass for drawings of precision (1872).
19. Steel callipers with vernier (1870).
20. Models of spikes with measuring wedges for the measurement of a base; invented by Bessel, constructed by Ertel (1874).
21. Models of rectilinear verniers for public instruction (1848).
22. Ebony pantograph from the workshop of the Royal Observatory of Padua (1830).
23. Rod Compass, by the distinguished mechanician Montan, of Padua (1824).

GROUP VI.—HYDRAULICS.

1. Model of a careening basin, constructed 70 years ago.
2. Model of a shell fitted in the Canale di Navigazione of Pavia; designed by Leonardo da Vinci (1485).
3. Hydrometrical pendulum of Venturoli, constructed by the engineer Albanesi, of Venice, in 1790.
4. Model of the Cremona regulator for dispensing water.
5. Model of the Piedmontese regulator for dispensing water.
6. Model of the regulator of the Milanese Bocca Magistrale for dispensing water.
7. Ball plummet, 30 mètres long, with small brass chain for centimètres and millimètres (1860).
8. Pilot tube, modified by Mallet, length 14 mètres, with float, constructed by the Royal Observatory of Padua (1852).
9. Tachymeter, of Brünnings, constructed in the workshop of the Royal Observatory of Padua, in 1483.
10 Portable hydrometer, in several pieces, length 8 mètres, of recent construction, to take the surface of the water of rivers with perfect accuracy, whence to deduce the declivity of the superficies, and to

introduce it into the hydraulic formulæ; constructed in the workshop of the Royal Observatory in 1874. The cabinet has three of them, which admirably answer the purpose.

11. Retrometrical rod, of Teodoro Bonati, of wood, composed of 10 pieces, constructed at the Royal Observatory of Padua in 1848.

12. Small mill by Woltmann, constructed in the workshop of the Royal Observatory of Padua in 1858.

13. Float, simple and compound.

14. Retrometrical Asta, of Teodoro Bonati, composed of tin tubes, 16 mètres long, divisible into 38 pieces of various lengths, constructed in 1859.

15. Pitot Tube, modified by Darcy, constructed by Sarran of Paris, in 1871.

16. Small mill of Woltmann, constructed in 1870, by J. Kern of Aaran, with two flyers and two wheels unequal in size.

17. Tachymeter of Brünnings, modified by Professor Turazza, constructed in the workshop of the Royal Observatory of Padua, in 1859.

4563. Photographs of Scientific Instruments in the Cabinet of Physical Science, Royal University of Padua.

Director, Prof. Rossetti.

(1.) INSTRUMENTS OF GALILEO.

a. Apparatus to demonstrate the theorem that a body falls in equal time from a chord and from the vertical diameter of a circle.

b. Telescope.

c. Atmospheric and water thermometer.

d. Natural loadstone, armed, weighs 2½ oz., supports 100 oz.

The scale is about mill. 100 to a mètre.

(2.) INSTRUMENT for dividing by Musschenbroeck, improved by Poleni, 1740–1760.

(3.) INSTRUMENT by s'Gravesande for central force; improved by Poleni, 1740–1760.

(4.) CONDENSING ELECTROMETERS, by Prof. Salvatore Dal Negro, 1804.

These instruments are interesting, historically; upon the results obtained by them, Dal Negro disputed the theory of Volta, and established from the first the foundations of the chemical theory of the pile. (*See* Description of a new electrometer and some experiments in charging the voltaic column, by Ab. Dal Negro, T. X. I., Italian Society of Science, Modena, 1804.)

(5.) 1 and 2. OLIGOCHRONOMETER, by Prof. Salvatore Dal Negro, applied to researches on the laws of weights falling freely. By cutting the thread which holds the weights suspended, the pendulum is set at liberty, which, being stopped by the weight arriving at the end of its course, cuts another thread.

3. Oligochronometer. (*See* New method for measuring the smallest fractions of time, invented by the Ab. Dal Negro, Padova, 1816. New Oligochronometer, Padova, 1809.)

(6.) MODEL OF OLIGOCRONOMETER, by Dal Negro, applied to the measurement of the velocity of projectiles. 1. Cannon, the ball of which on coming out of the mouth breaks a thread which sets the pendulum of the oligochronometer in motion (2). 3. Movable hinged target, which on being hit breaks a thread which stops the pendulum. 4. Details of the oligochronometer. (*See* New method for measuring the velocity of projectiles, 1824, by Sig. Ab. Dal Negro, Padova, 1824.)

(7.) 1. ELECTRO-MAGNETIC MOTOR, by Prof. Salvatore Dal Negro. Two permanent magnets suspended like a pendulum can oscillate in the proximity of the poles of a temporary magnet, in which the current circulates alternately in contrary directions, by means of a swinging commutator with small cups of mercury moved by the pendulum itself. The attractions and repulsions which result render the movement of the pendulum continuous, and this, by means of levers, is transformed into continuous rotatory motion. (*See* Description of electro-magnetic rams (arieti), both simple and compound, by Prof. Ab. Dal Negro. Padova, 1838. Also Annali delle Scienze del Regno Lombardo-Veneto, tomo III. bimestre I., 1838.)

2. Electro-magnetic Pendulum, by Prof. Dal Negro. The rod of the pendulum is formed by a bundle of permanent magnets, one extremity of which can oscillate between the poles of an electro-magnet. The inversion of the current is effected as in the above-described motor. This pendulum is interesting, historically, as recording the first attempts at using electricity as a motive power.

(8.) ELECTRO-MAGNETIC MOTOR, by Prof. Dal Negro. The apparatus consists of a lever of the first order, to one extremity of which is attached the anchor of an electro-magnet, and to the other a hammer which by alternate elevations and descents strikes a rod, and produces a movement like that of a shuttlecock, and afterwards the lifting of a weight. This movement of the lever produces the inversion of the current in the electro-magnet, and by means of a swing commutator with small cups of mercury. (*See* Description by Prof. Dal Negro, Padova, 1838, and in Annali delle Scienze del Regno Lombardo-Veneto, tomo VIII. bimestre 1°, 1838.)

(9.) 1. MACHINE for DIVIDING. (Salleron, Paris, 1870.)

2. Cathetometer of the Tecnomanasio of Milan, improved in the workshop of the Astronomical Observatory at Padua; added to it is an internal counterpoise.

3. Balance of precision, by Deleuil, of Paris.

4. Quadrant Areometer, by Poleastro (1803). It is a hydrostatic balance with quadrant. It is used to ascertain the density of fluids, and is much more correct than ordinary areometers.

5. Spherometer, by Brunner (1870).

6. Goniometer, by Babinet.

(10.) 1. Model of a Pump by suction and pressure.
2. Barometer, by Poleni (1740–1760).*
3. Barometer, by Amontons.
4. Barometer, by Cassini.
5. Barometer (quadrant).
6. Barometer of Fortin.
7. Barometer of Fortin, constructed by Bellani.
8. Syphon barometer, constructed by Bellani.

(11.) 1. Air-pump by suction and pressure, by Deleuil. Gives rarefaction to 2 mill., and compression to 10 atmospheres. The effect is double, and the piston does not touch the walls.
2. Differential manometer of Regnault.
3. Metallic manometer.

(12.) 1. Double Siren of Helmholtz (Kœnig, Paris).
2. Apparatus by Kœnig for the combination of vibrating forces. May also be used for the experiments of Lissajous.
3. Apparatus by Kœnig for the interference of sounds.
4. Organ pipes with manometrical capsules, by Kœnig.
5. Apparatus for musical flames.
6. Analyser of sounds (Kœnig).
7. Acoustic interrupter.

(13.) 1. Heliostat, made at Padua in 1828 by the younger Tessarolo, resembling, with modifications, that by Prandi. The reflected ray may be thrown in any direction. (*See* Opere Scient. di Bologna, 1824, p. 244, and Santini, Strumenti Ottici, vol. 1, Padova, 1828.)
2. Heliostat of Silbermann; made at Paris.
3. Lantern for electric light, with Foucault's regulator, constructed by Duboscq.†
4. Lamp for oxyhydrogen magnetic light, by Carlevaris.
5. Lamp for the Drummond light.
6. Regulator for electric light, by Archereau, with reflectors, invented by Prof. Rossetti so as to throw the light in all directions.

(14.) 1. Complete Optical Bank.
2. Microscope, by Hartnack.
3. Microscope, by Amici.
4. Microscope, by Plössl.
5. Dialytic telescope, by Plössl.
6. "Lentiprisma."
7. Prism for projections.
8. Spectroscope, for direct vision.
9. Bunsen's Spectroscope.

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* A constant level in the vessel is obtained by the immersion of a screw.

† To this is attached a projection microscope.

(15.) 1. Large APPARATUS for POLARISATION, made by Soleil.
2. Apparatus by Nörremberg.
3. Apparatus for polarisation, Biot.
4. Apparatus for polarisation, Arago.
5. Cianopolarimeter, Arago.
6. Apparatus for polarisation, by Malus.
7. Saccharometer, by Soleil.
8. Phosphoroscope, by Becquerel.

(16.) 1. ATMOSPHERIC THERMOMETER, by Jolly, made at Monaco.
2. Apparatus by Clement and Desormes.
3. Mercury calorimeter, by Favre and Silbermann.
4. Complete apparatus of Melloni, made by Ruhmkorff.

(17.) Working model of stationary STEAM ENGINE.

(18.) 1. COMPASS, by Prazmowsky, for measuring the intensity of the horizontal components of terrestrial magnetism.

2. Compass for declination.

3. Magnetic theodolite, of Lamont, made at Monaco. This instrument is portable, and serves to determine all the magnetic constants.

4. Apparatus, Faraday's, for diamagnetism.

(19.) 1. Large ELECTRIC MACHINE, by Winter, with two discs. Made at Vienna.

2. Machine, Holtz's, of the second kind, with horizontal discs. Made at the Tecnomanasi of Milan.

3. Double machine, Poggendorff's. Made at Berlin.

(20.) HOLTZ'S MACHINE, of the first kind, worked by a wheel.

It was used in this way by Prof. Rossetti to measure the amount of work employed to produce a current of given intensity, and for other experiments described in his memoir "Nuovi Studii sulle Correnti delle Macchine Elettriche" (Atti dell' Istituto Veneto, Vol. III., Ser. IV., 1874; Nuovo Cimento, Vol. XII., 1874. Ann. de Chim. et de Phys. T. IV. 1875., Journal de Physique, 1875).

(21) 1. RHEOTONU of Bréguet and Masson.
2. Sine compass.
3. Tangent compass.
4. Thermometer, Riess's.
5. Reometric Balance, Bernardi's.

A magnetic needle, working upon horizontal pivots, is surrounded by a frame, on which is wound a wire, and is united in action with the yoke of a sensitive balance. The intensity of the current traversing the wire is measured by the weight that must be placed in one of the scales of the balance, in order that the beam, and consequently the needle, may rest horizontally.

6. Galvanometer (vertical) for instruction.
7. Galvanometer of Du Bois Reymond, made by Sauerwald.
8. Torsion galvanometer.

(22.) 1. FOUCAULT'S APPARATUS for transforming heat into work by means of induced currents. Electricity.

2. Electro-magnetic motor, applied to Geissler's tubes.

3. Electro-magnetic motor, by Page.

4. Apparatus of De la Rive for the rotation of the voltaic arch.

5. Matteucci's induction coil.

6. Magneto-electric machine, by Stöhrer.

7. Dynamo-magneto-electric machine, by Ladd.

(23.) Large RUHMKORFF'S COIL, with Foucault's interrupter, and accessories; made at Paris. Gives sparks 40 centim. long.

(24.) 1. HYGROMETER, Regnault's.

2. Hygrometer, Daniel's.

3. Psychrometer.

4. Condensation hygrometer, Belli's. (*See* Belli, Elementary Course of Experimental Physics, Vol. II., Milan, 1838.)

5. Psychrometer, Belli's. (*See* Belli, Elementary Course of Experimental Physics, Vol. II., Milan, 1838.)

6. Parchment hygrometer, Bellani's.

7. Maximum and minimum thermometer, Bellani's.

8. Maximum and minimum thermometer, Walferdin's.

9. Atmidometer of Landriani, perfected by Bellani. (*See* Belli, Elementary Course of Experimental Physics, Vol. II., Milan, 1838.)

(25.) ROSSETTI'S APPARATUS for the display of luminous electric figures obtained by the discharge of positive or negative electricity upon the naked surface of a glass, the other surface of which is furnished with an armature. (*See* Di una curiosa esperienza elettrica:—Atti delle Società Veneto-Trentina di Scienze Naturali, Vol. I., 1872. Nuovo Cimento, Vols. V., VI., 1872. Carl's Repertorium der Physik, 1873. Journal de Physique, Paris, 1873, Novembre.)

4564. Photographs of Scientific Instruments in the Physical Cabinet of Science, University of Pavia.

Director, Prof. Giovanni Cantoni.

1. Small apparatus for the study of reciprocal electrical influence, with two electrometers. Volta.

2. Two electrophori which recharge themselves and work as unfailing sources of electricity (first example of an electric machine by induction). Volta.

3. Measurer of powerful electric tension, by Volta.

4. Apparatus for the study of the electric spark. Volta.

5. Apparatus for the dilatation of gaseous fluids. Volta.

6. Electric duplicator by Giuseppe Belli. (Attempt at an electric multiplier which served to introduce the next machine.)

7. Electric machine by induction, G. Belli. (First example of an electrometer by induction, somewhat like the first machine of Holtz).

8. Hygrometer, with durable indications (by the same).

9. Psychrometer with bellows (by the same).

10. Collector of atmospheric heat, with continuous indications, by Con. Bellani.
11. Psychrometer with continuous indications, by Con. Bellani.
12. Balance barometer, modified by Prof. Giovanni Cantoni.
13. Normal barometer for Meteorological Stations, by Prof. Giovanni Cantoni.
14. Psychrometer with ventilator, by Prof. Giovanni Cantoni.
15. Electric balance, by Prof. Giovanni Cantoni.
16. Electric scale, for the measurement of electrical adherence.
17. Maximum and minimum thermometer, by Prof. Giovanni Cantoni.
18. Anemometrograph, by Prof. Parnisetti and Ferd. Brusotti.
19. Modification of the machine of Attwood, by Ferdinand Brusotti.
20. Hygrometer worked with sulphuric acid, improved by Brusotti.

4565. Photographs of Scientific Instruments in the Royal Observatory of Palermo. *Director, Prof. G. Cacciatore.*

1. Great circle by Ramsden, 1790. The principal parts are, first, a vertical axis of conics, parallelopiped form, destined to support two graduated circles, one for altitude, the other for azimuth. 2nd. The upper support of this axis, formed of four columns with four arches, and a collar in the middle. 3rd. The lower support, composed of three circles placed horizontally one on the other. 4th. A balustrade. 5th. An achromatic telescope. 6th. Three microscopic micrometers, with other smaller pieces. (*See* annexed description by Piazzi)
2. Catalogue of the stars made by circle No. 1.
3. Equatorial, by Merz. (Aperture of object glass 9·665 inches.) Set up in 1865.
4. Spectroscopic observations by the above equatorial.
5. Seismograph of Niccolo Cacciatore, 1826. A circular receiver, perforated laterally in eight parts, indicating the four cardinal points, and the intermediate points. Placed on a perfectly horizontal plane, and filled with mercury which touches the holes, and which therefore can spill at the least oscillation, and in the direction of the oscillation. A corresponding number of small cups placed below the holes to receive the spilt mercury, which may afterwards be replaced. The mercury received in the cups indicates the undulatory shocks of earthquake.
6. Anemometer by Niccolo Cacciatore, 1832. Attached is a description of the instrument by the inventor.

4567. Photograph of Registering Evaporimeter, according to the last plan adopted by the inventor, Prof. Ragona.
Observatory of the Royal University of Modena; Director, Prof. Domenico Ragona.

4568. Photographs of Scientific Instruments in the Cabinet of Physical Science of the University of Naples.
Director, Prof. Giuliano Giordano.

1. Fresnel lens used by Melloni in his researches upon radiant heat, in particular with reference to the heat of the rays of the moon.
2. Floating plummet, by Paolo Anania de Luca.
3. A most accurate balance, by Bandini, machinist of the University, resembling that of Steinheil, but much less costly.

4569. Photographs and Drawings of Scientific Apparatus in the Vesuvian and Meteorological Observatory at Naples.

Director, Prof. Luigi Palmieri.

1. Portable seismograph by Palmieri, with a printed description.
2. Stationary seismograph, made by order of the Hydrographic Department of the English Admiralty, by Prof. Palmieri.
3. Stationary seismograph, made for the Vesuvian Observatory. (*See* explanatory note.)
4. Anemograph with hydrograph annexed, by Prof. Palmieri, with an illustrated description.
5. Bifilar electrometer and apparatus, with movable conductor, by the same, with two printed descriptions.

4570. Photographs of Scientific Apparatus.

University of Pisa; Director, Prof. Riccardo Felici.

Very ancient thermometer. It is impossible to say whether it works by water or alcohol. For graduation it has a string of glass beads. In the upper part are enamelled the characters, D. 20, A. 25.

II., III., IV. Galvanic chronographic interrupter, described in the Nuovo Cimento, t. xii., p. 115, and t. xiii., p. 266.* It opens and shuts successively electric circuits, measuring the intervals of time by the diapason (*d*), which by vibration marks by a stile the oscillations on the smoked cylinder (*c*). Perpendicular to the axis of the cylinder are eight rays, which rotate with it, and are furnished with small stops of steel isolated on ebonite. These, striking on the levers (*l*), detach them from the pieces (*p*) opening and closing the circuits, since a mechanical method of closing reduces itself to one of opening. For the ordinary way of closing, the piece (*g*) is used, which is to be found on fol. iii. (see description quoted). The surfaces of contact at the points of interruption are of silver, and to make them fit better the cylinders (*p*) are movable on their own axis. The diapason is movable around a horizontal axis (fol. iv.), and can slide along it. The plate which carries it is movable round a vertical axis; the correcting screw *h* can incline it slightly. The screw *z* regulates the contact of the stile with the cylinder. The piece *a*, which turns with the cylinder, at one point of the experiment meets the piece *b* lifting the diapason. The small bit of wood *s* serves to set the diapason in vibration. The base of the apparatus is of cast zinc, length 0·64, breadth 0·19 meter. The remainder is of brass, except the isolating pieces, which are of ebonite.

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* In the apparatus described in the Nuovo Cimento there is a Froment's Siren instead of the diapason, the piece *a* is wanting, and there are only two radii *r*.

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